# RADIOLOGY

A MONTHLY JOURNAL DEVOTED TO CLINICAL RADIOLOGY AND ALLIED SCIENCES

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## The Development of a Chest Phantom for Use in Radiologic Dosimetry[1]


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OUR INTEREST in the fabrication of a physically and anatomically realistic chest phantom was first stimulated by the work being done on supervoltage (2 mv) chest roentgenography by one of the authors (11, 12). In the course of investigations of the value of supervoltage technics in the detection of thoracic lesions, it became apparent that such a phantom was needed for two basic reasons: first, to permit the measurement of integral dose received by a patient at 2 mv compared to that absorbed during a similar examination at the usual diagnostic energy levels; second, for use in the comparative evaluation of diagnostic technics.

Previous work by Weatherwax (14), Quimby (9), Granke (4), and Nahon (8) involving chest phantoms for dose measurements has contributed greatly to an understanding of intrathoracic dosage. None of the earlier phantoms, however, were suitable for use at energy levels below 200 kvp, and in none was there sufficient anatomic detail to permit the investigation of diagnostic technics.

The purpose of this paper, therefore, is to describe a chest phantom which, with respect to effective atomic number, mass density, and anatomic detail, closely resembles the human thorax. The materials and methods used in its construction, and its applications in diagnostic and therapeutic radiology will be discussed.

### EVALUATION OF PHANTOM MATERIALS

A. *Materials to be Used for the Soft Tissues of the Chest Wall:* The criteria for choosing materials to be tested for use in simulating the soft tissues of the chest wall were an effective atomic number (Z) and density comparable to those of tissue, 7.33 (10) and 1.00 (2), respectively. Water approximates these values very closely and therefore, as a final measure of the suitability of the various substances, their radiographic density and homogene-


[1] From the Department of Radiology, Hospital of the University of Pennsylvania, Philadelphia, Penna. Presented at the Forty-first Annual Meeting of the Radiological Society of North America, Chicago, Ill., Dec. 11–16, 1955.

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TABLE I: COMMONLY EMPLOYED PHANTOM MATERIAL. COMPARISON OF EFFECTIVE ATOMIC NUMBER AND DENSITY

| Material | Density (gm./c.c.) | Effective Atomic Number (Z) |
|---|---|---|
| Water | 1.00 | 7.42 |
| Masonite | 1.01 | 6.83 |
| Paraffin | 0.92 | 5.41 |
| "Mix D" | 1.00 | 7.32 |
| Tissue* | 1.00 | 7.33 |

* Mayneord.

compound called "Mix D," which has an effective atomic number of 7.32 and a mass density of 0.99, composed of paraffin, polyethylene, magnesium oxide and titanium dioxide. While the Z and mass density are ideal, the mixture is difficult to prepare and is not handled easily. Polyethylene solidifies rapidly around 140° C., precluding the moulding and shaping required to represent adequately the distribution of the absorbing masses of the

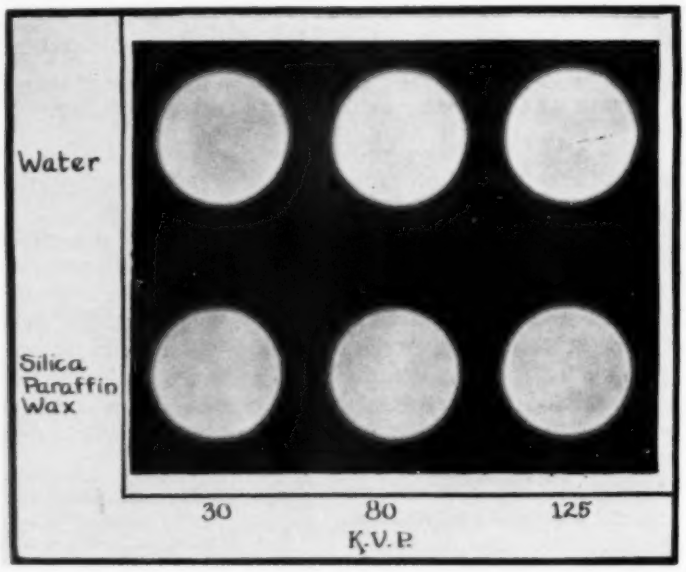



Fig. 1. Comparison of densities of paraffin-$SiO_2$ mixture and water, of equal thickness, at 30, 80, and 125 kvp. Note the homogeneity of the paraffin-$SiO_2$ test objects.

ity were compared to those of an equal thickness of water. Exposures were made at various energy levels and the shadows compared visually and photodensitometrically.

Additional factors considered were adaptability, ease of handling and fabrication, durability, strength, uniformity (reproducibility), and availability of the materials.

1. Paraffin and dental wax meet the secondary criteria, but are deficient in effective atomic number (5.41) and mass density (0.92).

2. Jones and Raine (6) described a chest wall. At room temperature, the mixture is quite hard and is not readily shaped without the use of power tools. In addition, with the use of commonly available laboratory apparatus, it was impossible to obtain a homogeneous distribution of the solid components throughout the liquid paraffin-polyethylene mixture. Because of rapid solidification, air was trapped within the mass, resulting in undesirable defects in test objects.

3. Rubber products, both natural and synthetic, were considered. It is theoretically possible to prepare a rubber compound having the correct effective atomic

TABLE II: MATERIALS CONSIDERED FOR TISSUE-EQUIVALENT AND BLOOD-EQUIVALENT SUBSTITUTES

Note the values of the effective atomic number and density of the paraffin-$SiO_2$ and plastic-$SiO_2$ mixtures compared to the same values for tissue.

| Material | Density (gm./c.c.) | Effective Atomic Number (Z) | Homogeneity | Summary |
|---|---|---|---|---|
| Tissue | 1.00 | 7.33 | | |
| Paraffin<br>Dental Wax | 0.92 | 5.44 | Good | Low Z<br>Low density |
| "Mix D" | 1.00 | 7.32 | Poor | Difficult handling |
| Isoprene + ZnO + S | .. | 7.32 | ... | Difficult handling<br>High temperature "curing" |
| Vinyl Acetate | .. | 6.62 | Good | 70 to 80 per cent shrinkage<br>Extreme brittleness |
| Liquid Latex | .. | .. | Good | 50 per cent shrinkage<br>Extreme flexibility |
| Paraffin + $SiO_2$ (19 per cent) | 0.98 | 7.30 | Good | Excellent Z and density<br>Homogeneous<br>Ease of handling |
| J-17* + $SiO_2$ (5 per cent) | 1.19 | 7.20 | Good | Good Z and density<br>Homogeneous<br>Regulation of flexibility |

* Methyl methacrylate polymer.

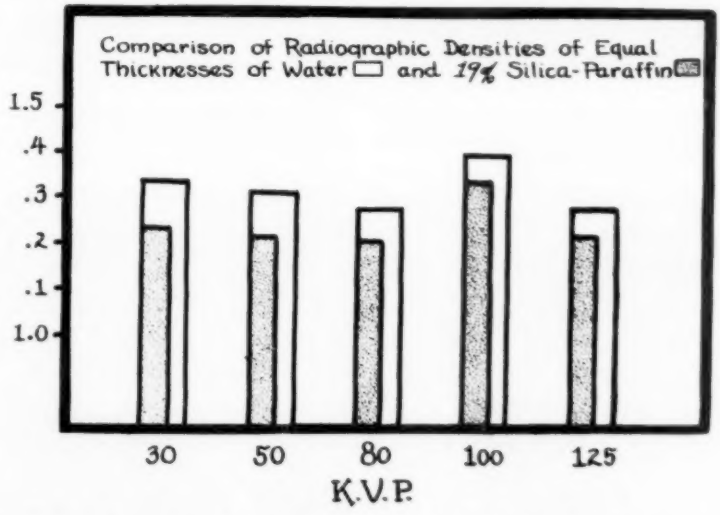



Fig. 2. Comparison of photodensitometrically determined radiographic densities of the test objects in Fig. 1. The difference in density can be attributed to the difference in effective atomic number, that for water being 7.42 and for silica-paraffin mixture 7.30.

number. There is, however, no practical method of applying the "cured" elasticizer to the chest wall or for utilizing it in the fabrication of the mediastinal structures.

4. "Chlorowax-70"[7] is a chlorinated paraffin containing 70 per cent (by weight) of chlorine. A mixture of 8.3 per cent Chlorowax-70 in paraffin, according to a modification of Spiers' formula, has an effective atomic number of 7.32. In these proportions, however, a grossly inhomogeneous mixture results. No attempt was made to determine the mass density.

5. Diatomaceous earth is composed of over 99 per cent silicon dioxide and has an effective atomic number of 11.56. It has been calculated that 19 per cent silica in

[7] Diamond Alkali Co., New York, N. Y.

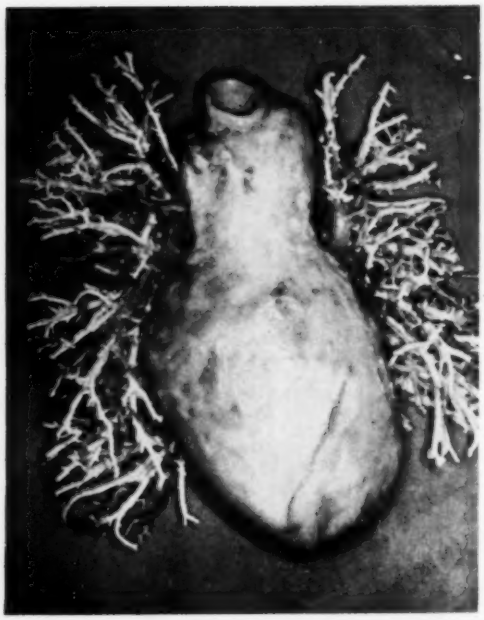
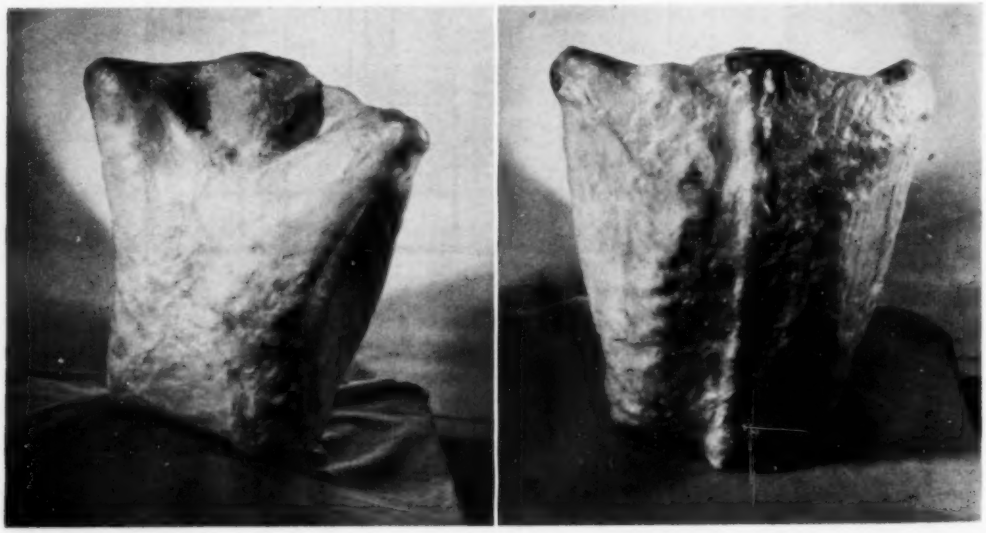


Fig. 3. Completed mediastinal unit prior to insertion within the thoracic cavity. The tracheal lumen can be seen to the right of the aortic arch.

ture compared quite favorably with that of an equal thickness of water, with x-ray beams as low as 28 kev effective photon energy. The particle size of diatomaceous earth is 0.2 mm. or less and, therefore, a homogeneous dispersion is readily obtained. Roentgenograms of test objects revealed no significant discrete particles. Test objects were prepared from different lots of the mixture and particle dispersion was found to be uniform. In addition, the radiographic and physical densities varied not more than 2 per cent in ten different samples. Because of the viscosity of the mixture in the liquid state, it is easier to apply than molten paraffin; this affords shorter working time and greater ease of handling. In the solid state, the mixture can be shaped as readily as paraffin. Its greater cohesion permits precision cutting with power tools and affords greater durability than that of paraffin.

B. *Materials to Represent Cardiovascular Structures:* The criteria employed in evolving a satisfactory soft-tissue substitute, namely, effective atomic number and density, were used also in the choice of materials to represent the cardiovascular struc-



Figs. 4 and 5. Anterior and posterior views of the phantom, which has been constructed in the position normally assumed for routine chest roentgenography.

paraffin results in a mixture with a Z of 7.30. The physical density as determined by water displacement is 0.98. The radiographic density of test objects of this mix-

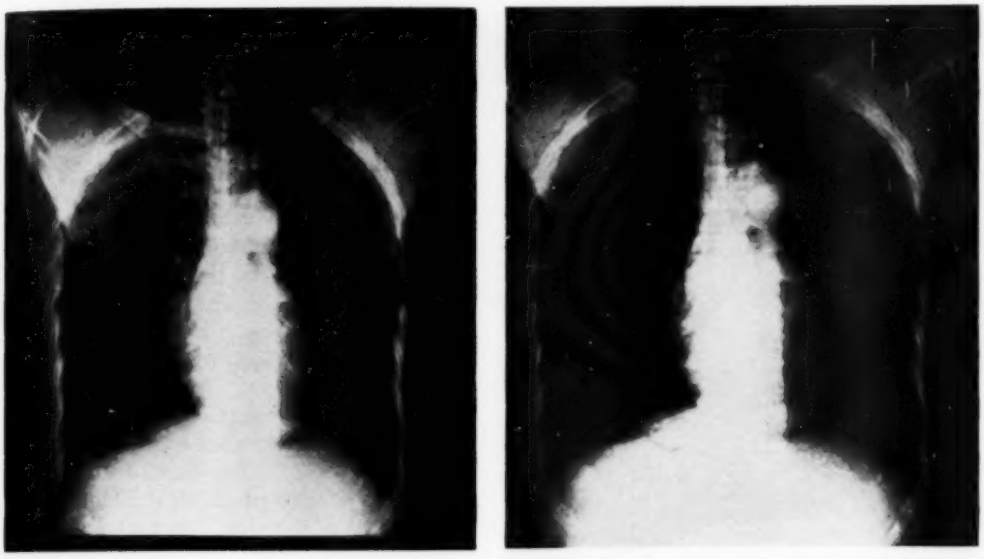


Fig. 6. *Left:* Postero-anterior projection of the phantom. Factors: 80 kvp, 1/20 second, 100 ma, 72 inches T.F.D., non-Bucky.
*Right:* Overpenetrated Bucky roentgenogram made in the postero-anterior projection.

tures. Because paraffin solidifies rapidly at low temperatures, the silica-paraffin mix is not suitable for injection purposes.

1. A corrosion specimen of the cardiac chambers and the pulmonary vascular system provides the best anatomical representation of these structures. Liquid latex and vinyl acetate[8] are commonly employed injection media, and each was injected into the vascular system of several different lungs. Latex proved to be unsatisfactory for several reasons; shrinkage is as much as 50 per cent, and the material is attacked by strong acid and alkali, thus precluding corrosion except by the slow method of bacterial maceration. Finally, after dissecting the surrounding pulmonary parenchyma, the latex failed to support its own weight. Vinyl acetate has the disadvantages of relatively low Z (6.62) compared to that of tissue, 70 to 80 per cent shrinkage, and extreme brittleness.

2. Batson (1) has made use of a methyl methacrylate corrosion mass[9] with very satisfactory results. It has two main advantages over the vinyl masses: shrinkage is only about 15 per cent and may be compensated for by slight overdistention during injection; the degree of flexibility (or brittleness) may be predetermined by varying the amount of "promoter" added prior to injection. A 5 per cent mixture of diatomaceous earth and the injection mass described above has an effective atomic number of 7.2 and a mass density of 1.19. Test objects of this mixture have demonstrated the same degree of homogeneity and reproducibility as were found in the silica-paraffin mixture.

C. *Preparation of the Osseous Thoracic Cage:* A musculo-ligamentous specimen was prepared from the bony chest cage of a fresh, unembalmed cadaver. Included in the specimen, in addition to the ribs and vertebrae, were the scapulae and clavicles. In order to preserve the tissues without altering their effective atomic number and density, formalin was employed as the fixative agent. The marrow cavity of each bone was injected with 33 per cent formalin, after which the entire specimen was immersed in 15 per cent form-

[8] Ward's Natural Science Establishment, Inc., Rochester, N. Y.
[9] "J-17" prepared by H. D. Justi & Son Co., Philadelphia 4, Penna.

Fig. 7. Roentgenogram of phantom in the lateral position. Factors: 100 kvp, 1/10 second, 100 ma, 50 inches T.F.D., screen and Potter-Bucky diaphragm.

alin for seven days. Reinforced paraffin applied to the specimen prevented evaporation of water and formalin from the tissues. Comparison of roentgenograms made immediately following dissection and after fixation revealed the density of the bones to be identical.

### TECHNIC OF ASSEMBLING PHANTOM

Fresh cadaver material was used in preparation of the corrosion specimen representing the heart and pulmonary vascular system. The thoracic organs were removed *en bloc*. The distal end of the aorta and the vessels arising from it were ligated, as were the inferior vena cava and azygos vein. A large-bore glass cannula was secured in the right atrium through the superior vena cava and another was placed in the left atrium.

The technic for preparation of the corrosion specimen is a modification of that described by Liebow (7). A pressure-cooker, previously fitted with a gas stopcock on the bottom, serves as a reservoir for the silica-plastic mixture. Air from a compressed-air pump is introduced into the reservoir through a valve fitted to the top of the cooker. The plastic mixture is forced through the cannula in the superior vena cava, filling the right side of the heart and the pulmonary arteries. Following clamping of the superior vena cava cannula, the tube from the gas stopcock is connected with the cannula in the left atrium. The plastic-silica mixture is then forced into the left side of the heart, pulmonary veins, and aorta. After filling of these structures, the cannula is clamped and the pressure-cooker excluded from the system. The pump is connected directly to a short piece of pipe tied in the trachea, and the flow of air is regulated to maintain the lungs in their normally expanded state. The pressure is maintained for twenty-four to forty-eight hours until the pulmonary parenchyma has dried. At this point, the specimen may be subjected to maceration. Within thirty-six to seventy-two hours the corrosion specimen is ready for cleaning with a fine stream of water. Injection of the silica-Justi plastic mixture must be completed in twenty to thirty minutes because the plastic begins to harden within that interval after mixing. Re-injection, as advocated by Liebow to compensate for shrinkage of the plastic with hardening, is not necessary if the vessels are slightly overdistended at the time of injection.

To the "heart-lung" preparation described above, must be added the "trachea," "bronchi," and "myocardium." For each of these, the silica-paraffin mixture was utilized. The "trachea" and "stem bronchi" are represented by hollow tubes of the tissue-equivalent paraffin mixture. These were formed by making a tubular mold, sealed at one end, into which the molten silica-paraffin mixture was introduced. A wooden core, previously shaped in the configuration and dimensions of the tracheal lumen, was inserted into the center of the paraffin column. When the mixture had hardened, the mold and wooden core

were removed, leaving a hollow tube of tissue-equivalent material. The walls of the "trachea" were reduced to the proper thickness with a sharp knife. The same general plan was used to construct the "stem bronchi."

The three pieces ("trachea" and "bronchi") must then be applied to the "heart-lung" preparation. This is best accomplished by locating the smaller ends of the "bronchi" in their correct relationship to the hilar vessels of the corrosion specimen. The larger, or proximal, ends can then be moved to relation to one another until the proper anatomic angulation of each "stem bronchus" is obtained and a "carina" formed. These are fused together by warming the proximal ends. The distal end of the trachea can then be cut to fit the angle formed by the proximal ends of the "stem bronchi." The "trachea" is placed to the right of the aorta and the distal end fitted in place. The paraffin mixture is again heated to fuse the "trachea" to the "stem bronchi" and to the "aorta."

Fig. 8. Supervoltage (1 mv) postero-anterior projection of phantom. The relative densities of bone, "soft tissue," and air-containing "lung" compare favorably with the same densities in Fig. 9.

To represent the myocardium, silica-paraffin mixture is applied to the surface of the cardiac cast. Care must be exercised to force the mixture into the indentations made by the papillary muscles in the corrosion specimen. Air trapped in these sites produces undesirable radiolucent areas in the cardiac shadow on the roentgenogram.

Fig. 9. Supervoltage (1 mv) postero-anterior projection of human chest measuring 2 cm. greater than the phantom in the anteroposterior diameter.

The muscles of the chest wall are represented by the silica-paraffin mixture. Before this is applied, heavy aluminum foil is temporarily tied to the inside of the ribs to serve as a base upon which to place the tissue-equivalent mixture.

It has been found useful, in placing the completed "heart-lung-trachea" unit within the chest, to secure the unit temporarily with strings brought out through the thoracic inlet and tied to the cervical spine. Roentgenograms made in the postero-anterior and lateral projections will then serve as a guide in obtaining the desired anatomic relationships within the thorax. When final adjustments have been made, the unit is fused in place by pouring heated silica-paraffin mixture behind the trachea and plain paraffin between the left ventricle and the bodies of the thoracic vertebrae. This not only fuses the unit to the vertebral column, but serves as a representation of the posterior mediastinal contents.

Representation of the heart and pul-

monary vascular system by a corrosion specimen of these structures precludes the presence of pulmonary parenchyma as part of the mediastinal unit. In order to supply the effect of pulmonary parenchyma on the incident beam, #00000 empty, clear gelatin capsules[10] were poured into the thoracic cavity. These were worked between the pulmonary vessels and filled the spaces between the vessels and the chest wall. The effective atomic number of the gelatin of which the capsules are formed is 7.0. Their density of 0.15 is in close agreement with the previously estimated pulmonary tissue density of 0.2 (13).

The final step in completing the phantom is the representation of the diaphragm and subdiaphragmatic organs. This is accomplished by fusing sheets of dental wax in the shape and location of each hemidiaphragm. After cooling, lining the accessible surface of the dental wax with aluminum foil localizes its distribution on postero-anterior and lateral roentgenograms. When the "diaphragm" has been satisfactorily situated, the aluminum is removed and silica-paraffin mixture poured into the concavity. Since the thickness of the dental wax is between 1 and 2 mm., its effect on the dosage distribution is negligible.

## DISCUSSION

Phantoms previously employed for intrathoracic dose measurement have been an inflated lung immersed in a water phantom (14), a formalin-preserved cadaver (8), Masonite shaped as a thorax with balsa wood representing the lung tissue (4), and plywood, similarly shaped (8). While yielding valuable and significant information, these phantoms lacked anatomic detail and, because of the physical properties of their component parts, their practical applications were limited to energy levels of 200 kvp or higher.

At low energy levels (80 to 120 kvp) the interaction of radiant energy with matter is characterized by the photoelectric effect. This phenomenon may be expressed by the equation $\frac{\tau}{\rho} = k\frac{Z^3}{E}$ (5), where $\frac{\tau}{\rho}$ is the photoelectric absorption coefficient, $Z$ the effective atomic number of the matter being irradiated, $E$ the energy of the incident beam, and $k$ a proportionality constant. In this range, therefore, the absorption of the incident x-ray beam is extremely dependent upon the effective atomic number of the irradiated material and the beam quality.

At high energy levels (above 200 kvp), the interaction of photons with matter is primarily that of Compton scatter. This form of interaction depends mainly upon the number of electrons per gram of irradiated matter (electron density). Since most atoms have the same ratio of atomic number to atomic weight, Compton scatter is primarily a function of mass density and is not appreciably affected by atomic number. This effect becomes most important in tissue absorption at 200 kvp, and for 2 mv x-rays it is the only significant form of interaction between tissue and the x-ray beam. Therefore, chest phantoms prepared from materials which fail to approximate both $Z$ and mass density of tissue will not accurately portray absorbed dose throughout the broad energy spectrum desired. The tissue-equivalent materials used in the preparation of our phantom meet these requirements and make possible the comparison of dose measurements at all energy levels in the same phantom. The relatively low $Z$ of Masonite and plywood (6.83) precludes their use as accurate tissue-equivalent materials at energy levels below 200 kvp (3, 4).

The comparative evaluation of diagnostic technics demands a standard, anatomically accurate subject. Obviously, patients cannot be used for this purpose on account of the danger of overexposure, the marked variation in thoracic anatomy from patient to patient, and the inability to place test objects at desired sites within the chest. The use of a phantom eliminates the problems of overexposure and the positioning of test objects. While

[10] Eli Lilly & Company, Indianapolis, Ind.

previously described phantoms were satisfactory in these respects they were deficient as to intrathoracic anatomic detail. The insertion of a blood-equivalent cast of the heart and pulmonary vascular system and the representation of the other mediastinal structures in their proper anatomic relationships by tissue-equivalent material provide the anatomic detail so necessary for the objective investigation of diagnostic technics. Test objects placed in the mediastinum, for example, will be surrounded and obscured by structures that normally obscure lesions in this area. In the development of a technic to better demonstrate these lesions, the conditions involved will approximate those found in man.

Absorbed-dose and depth-dose measurements cannot be made using patients as standards. This is particularly true in the comparison of the dosage received in similar diagnostic procedures at various energy levels and in the different forms of therapeutic radiology. By placing ionization chambers in the lumen of the trachea or stem bronchus, direct comparison of the dosage delivered to a point in the mediastinum by rotational and multiple portal therapy is possible. Chambers placed in the lung fields and behind ribs will give a more reasonable estimation of the dose delivered to the pulmonary parenchyma and the effect of bone upon the penetrating beam.

## SUMMARY

A chest phantom constructed of materials enabling it to be used over an energy distribution of 80 kvp to 2 mv has been described. It consists of a soft-tissue-equivalent mixture of 19 per cent silica in paraffin and a blood-equivalent corrosion mass of 5 per cent silica in a methyl methacrylate plastic. The effective atomic number and mass density of the former are 7.30 and 0.98 respectively, while those of the latter are 7.20 and 1.19. These values compare favorably with those of tissue, which are 7.33 and 1.00 respectively.

The construction of the phantom is given in detail and a few of its applications are briefly mentioned.

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*(Para el sumario en español, véase la página siguiente)*

SUMARIO

**La Elaboración de un Fantasma Torácico para Empleo en la Dosimetría Radiológica**

Descríbese un fantasma torácico construído de materiales que permiten usarlo para una distribución de energía que varía de 80 kvp a 2 millones de voltios. Consiste en una mezcla de equivalente-de-tejido-blando compuesta de 19 por ciento de sílice en parafina y una masa corrosiva de equivalente-de-sangre compuesta de 5 por ciento de sílice en un plástico de metacrilato de metilo. El número atómico efectivo y la densidad de masa de la primera son 7.30 y 0.98, respectivamente, mientras que los de la última son 7.20 y 1.10. Estas cifras se comparan favorablemente con las del tejido, que son 7.33 y 1.00, respectivamente.

Se describen a fondo la construcción del fantasma y algunas de sus aplicaciones. Estas comprenden valuación comparada de las técnicas de diagnóstico y las mediciones de dosis absorbida y dosis a profundidad en procedimientos de diagnóstico semejantes a varios niveles de energía y en las diversas formas de terapéutica radiológica.

# Relationship of Roentgenographic Findings to Hemodynamics in Mitral Stenosis[1]

S. SCHORR, M.D., S. Z. ROSENBERG, M.D., M. ELIAKIM, M.D., and K. BRAUN, M.D.

IT WOULD BE OF great aid to the clinician and cardiac surgeon if it were possible to estimate the degree of pulmonary hypertension by routine roentgenographic examination of the heart and lungs. In the study to be reported here an attempt was made to determine the relationship of the size and appearance of the pulmonary artery, the lung fields, and the various heart chambers to the hemodynamic data obtained by cardiac catheterization in cases of mitral stenosis.

## MATERIAL AND METHOD

Fifty patients suffering from rheumatic mitral stenosis of varying degrees of severity were studied clinically, roentgenographically, and by right heart catheterization. In 32 cases the diagnosis of mitral stenosis was confirmed at operation.[2] In no instance were there clinical symptoms or signs of rheumatic activity. Six patients had atrial fibrillation.

Each patient was examined fluoroscopically, and esophagograms and postero-anterior, right anterior oblique, and left anterior oblique roentgenograms of the chest (2 m. focus-film distance) were obtained. The changes in the appearance of the heart, pulmonary artery, hilar markings, and lung fields were evaluated by the roentgenologist without knowledge of the hemodynamic data.

Prior to cardiac catheterization sedation was employed and every effort was made to dispel anxiety. Pulmonary "capillary," pulmonary artery, right ventricular, and right atrial pressures were recorded in succession by means of a Sanborn electromanometer; mean pressures were determined by electrical integration. The zero point for determining pressures was approximately 5 cm. below the angle of Louis. The pulmonary artery mean pressure (PAm) was considered to be normal or only slightly elevated when it was less than 30 mm. Hg, moderately elevated when between 30 and 49 mm. Hg, and markedly elevated when it exceeded 50 mm. Hg.

The pulmonary blood flow (PBF) was estimated according to the principle of Fick. The pulmonary vascular resistance (PVR) was calculated according to the equation:

$$\text{PVR (dynes sec.cm.}^{-5}) = \frac{\text{PAm} \times 1332 \times 60}{\text{PBF (c.c./min.)}}$$

(normal range 150 to 300)

The estimation of the pulmonary arteriolar resistance (PAR) was based on the equation:

$$\text{PAR (dynes sec.cm.}^{-5}) = \frac{\text{PAm} - \text{PCm} \times 1332 \times 60}{\text{PBF (c.c./min.)}}$$

(normal range 50 to 150)

PCm indicates pulmonary "capillary" mean pressure.

The assumptions on which these calculations are based are discussed by Gorlin *et al.* (3).

Comparisons between various roentgen findings and hemodynamic data are presented in graphs, where the ordinate records the values obtained by cardiac catheterization and the abscissa expresses grading of the x-ray findings, N indicating normal; + mild; ++ moderate; +++ marked.

## RESULTS AND COMMENT

*Size of Pulmonary Artery and Hemodynamic Data:* A tendency was found

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[2] Mitral valvotomies were performed by H. Milwidsky, M.D., head of the Department of Thoracic Surgery.

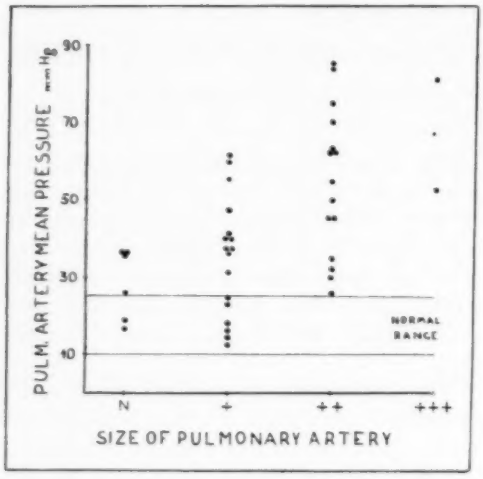


Fig. 1. Correlation between the size of the pulmonary artery and the pulmonary artery mean pressure.

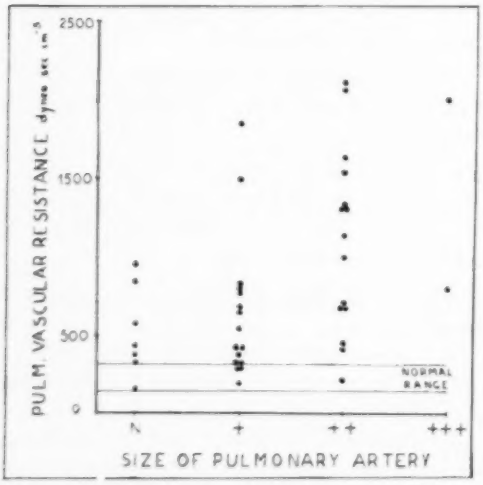


Fig. 2. Correlation between the size of the pulmonary artery and the pulmonary vascular resistance.

toward increase in the size of the pulmonary artery with rise in the PAm (Fig. 1). In a few cases, however, the artery was normal in size even though there was mild pulmonary hypertension. On the other hand, moderate enlargement of the artery was found in some cases with only mild pulmonary hypertension.

Increase in pulmonary artery size was generally accompanied by rise in PVR (Fig. 2) and PAR (Fig. 3). When the artery was moderately or markedly enlarged, both PVR and PAR were increased. Sometimes, despite normal appearance of the artery, PVR and PAR were increased.

*Hilar Markings, Lung Fields, and Hemodynamic Data:* Increase in the size of the

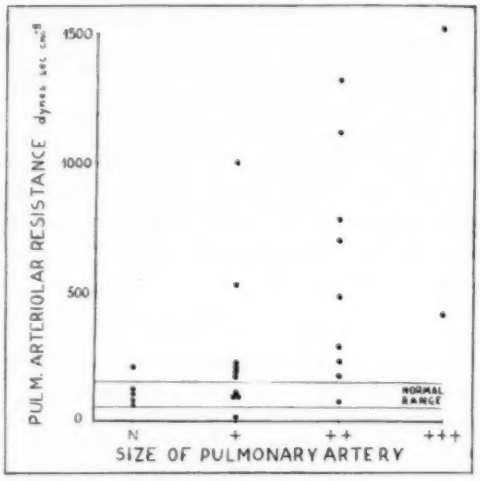


Fig. 3. Correlation between the size of the pulmonary artery and the pulmonary arteriolar resistance.

hilar markings was observed when there was an increase in the PAm, PVR, and PAR (Figs. 4–6). The appearance of peripheral lung fields, however, did not correlate well with either the PAm, PCm, or the PAR (Figs. 7–9). They frequently showed normal or only slightly increased density in the presence of severe pulmonary hypertension.

*Heart Size and Hemodynamic Data:* Increase in heart size was generally accompanied by pulmonary hypertension (Fig. 10). Normal heart size was found in a few cases with mild or moderate hypertension in the lesser circulation. The cardiac index (PBF/sq.m.) varied inversely with the size of the heart (Fig. 11).

Enlargement of the heart was accompanied by increased right ventricular mean pressure (RVm) and PVR (Figs. 12 and 13). In a number of cases, however, the heart appeared to be normal in size although the RVm and PVR were elevated.

There was a tendency to enlargement of

the left atrium with increase in the PCm (Fig. 14), though in some cases with only slight left atrial enlargement the PCm was extremely high. Correlation between the size of the left atrium and the PAR was poor (Fig. 15), patients with left atrial enlargement showing a PAR range from

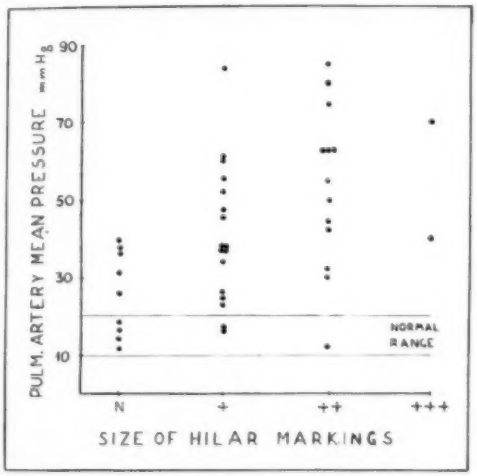


Fig. 4. Correlation between the size of the hilar markings and the pulmonary artery mean pressure.

normal to very high levels. In some cases with an enlarged left atrium and a high PCm, the PAR remained normal. Most of this latter group suffered from atrial fibrillation and heart failure.

## DISCUSSION

Comparative studies between the x-ray appearance of the heart in mitral stenosis and the hemodynamic data obtained by cardiac catheterization have usually been concerned with correlation of the size of the pulmonary artery with the pressure within it. Healey *et al.* (4) found a good correlation between the size of the pulmonary artery and the degree of pulmonary hypertension. Wood (9) reported that with progressive rise of the pulmonary artery pressure, the pulmonary artery becomes increasingly prominent. Steiner and Goodwin (7) found the size of the main pulmonary artery to correlate well with the degree of pulmonary hypertension,

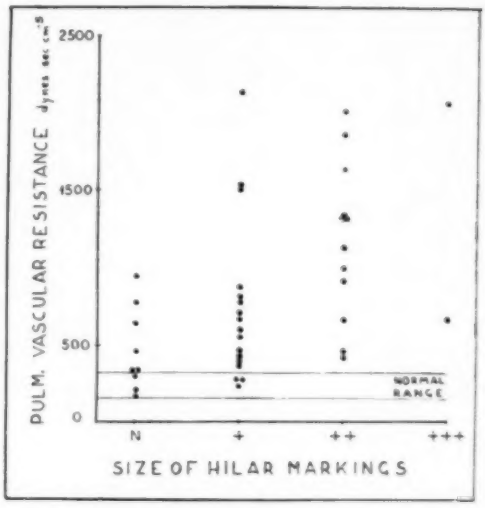


Fig. 5. Correlation between the size of the hilar markings and the pulmonary vascular resistance.

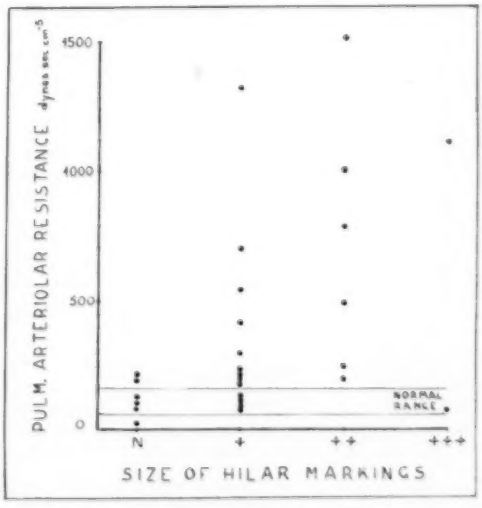


Fig. 6. Correlation between the size of the hilar markings and the pulmonary arteriolar resistance.

especially when the latter was moderate or severe. Lewis *et al.* (5) also observed a constant enlargement of the pulmonary artery in cases of severe pulmonary hypertension. In patients with normal or moderately elevated pulmonary artery pressures, however, the degree of enlargement of the pulmonary artery varied considerably. Bayliss *et al.* (1) stated that no

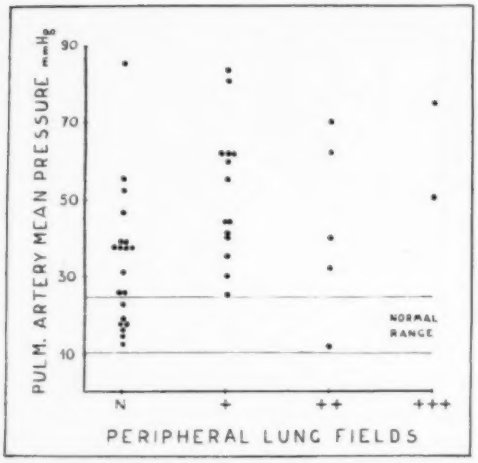


Fig. 7. Correlation between the peripheral lung fields and the pulmonary artery mean pressure.

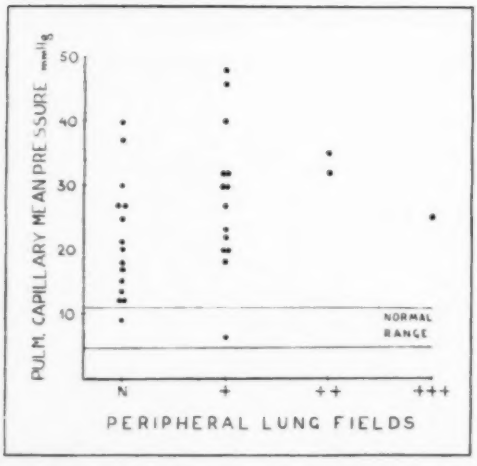


Fig. 8. Correlation between the peripheral lung fields and the pulmonary "capillary" mean pressure.

direct correlation existed between the size of the pulmonary artery and the degree of pulmonary hypertension.

Wade and his collaborators (8), in an extensive study on the hemodynamic basis of the symptoms and signs in mitral valvular disease, found a good correlation between the size of the left atrium, the right ventricle, and the pulmonary vessels in the hili and periphery, with the corresponding pressures and with the blood flow. They observed that enlargement of the right ventricle and increase of the hilar markings were generally associated with mean pulmonary artery pressures higher than 30 mm. Hg. Radiological evidence of congestion in the peripheral lung fields was accompanied by increased pulmonary "capillary" mean pressure. The left atrial enlargement was not closely related to the

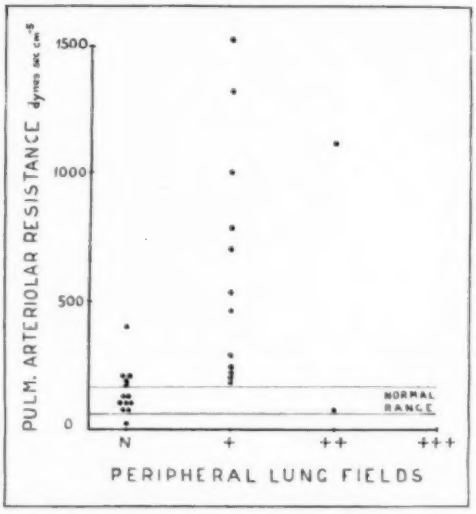


Fig. 9. Correlation between the peripheral lung fields and the pulmonary arteriolar resistance.

pulmonary "capillary" mean pressure and was greatest in cases of atrial fibrillation.

In this study an enlarged pulmonary artery and increased hilar markings were usually accompanied by high mean pulmonary artery pressure and increased pulmonary vascular and arteriolar resistances. It may be assumed, therefore, that high pressure or increased resistance in the lesser circulation may be responsible for enlargement of the pulmonary artery. In those cases where the pulmonary artery was markedly enlarged and the pulmonary artery mean pressure was only slightly elevated, heart failure accompanied by low cardiac output was present. There were some cases with an enlarged pulmonary artery, high pulmonary artery mean pressure, and normal or only slightly increased arteriolar resistance. In these patients arteriolar spasm was apparently not of considerable degree, and it is notable that

they all had heart failure. In the few cases, in which the pulmonary artery appeared to be normal roentgenographically in spite of increased pulmonary artery pressure and high resistances, we believe that the pulmonary hypertension was of short duration. The same reasoning may be

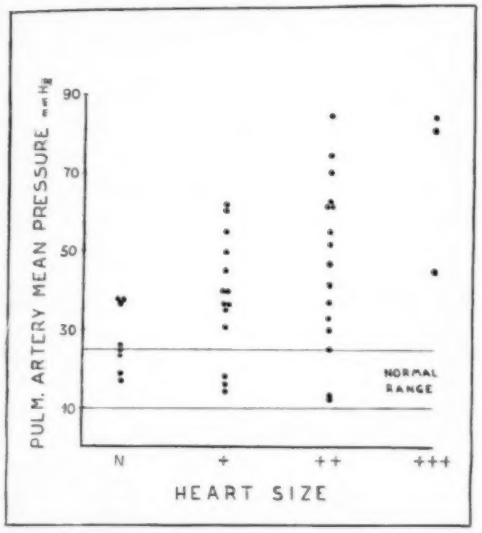


Fig. 10. Correlation between the heart size and the pulmonary artery mean pressure.

applied in comparison of the heart size with the pulmonary artery mean pressure, pulmonary vascular resistance, and the right ventricular mean pressure.

Radiologic evidence of peripheral pulmonary congestion was always accompanied by increased pulmonary artery and "capillary" mean pressures and/or high pulmonary arteriolar resistance. This finding is in accordance with the observations of Wade *et al.*, who found high pulmonary vascular resistance in cases with peripheral lung congestion.

A noteworthy observation was the very high pulmonary artery and "capillary" mean pressures in patients with normal peripheral lung fields and without clinical evidence of pulmonary edema. In all these cases the pulmonary arteriolar resistance was very high. Apparently the increased arteriolar resistance protected the

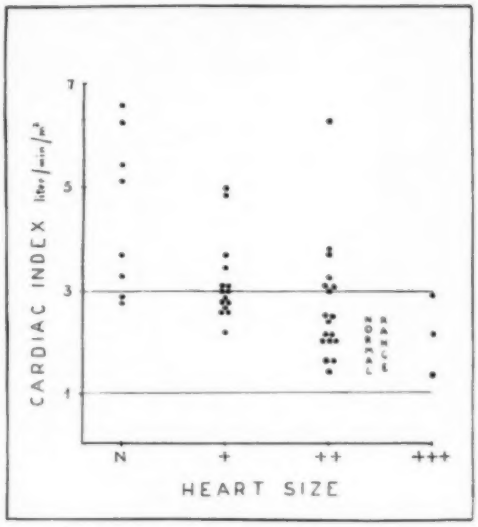


Fig. 11. Correlation between the heart size and the cardiac index.

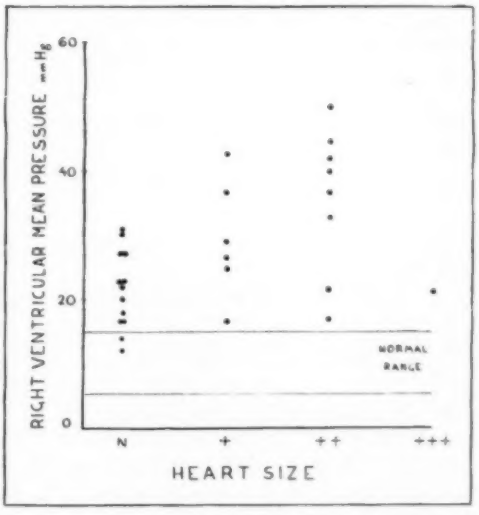


Fig. 12. Correlation between the heart size and the right ventricular mean pressure.

capillaries from additional rise in pressure, and thus prevented pulmonary edema. Pulmonary "capillary" mean pressures of 35 mm. Hg or more have been observed without clinical evidence of pulmonary edema (6) and 2 such cases in our series even had normal peripheral lung fields. Thickening of the pulmonary capillary wall

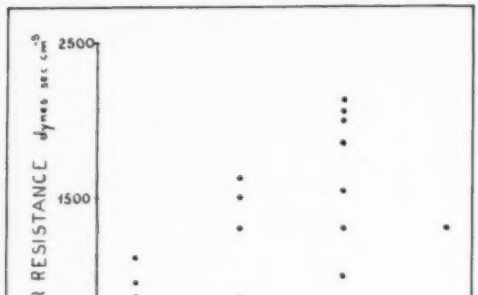


Fig. 13. Correlation between the heart size and the pulmonary vascular resistance.

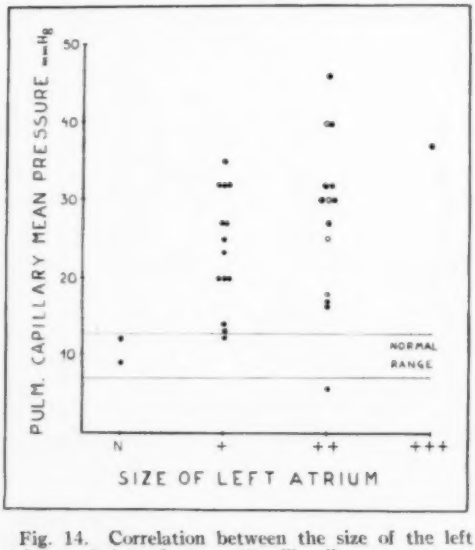


Fig. 14. Correlation between the size of the left atrium and the pulmonary "capillary" mean pressure. ○ = cases with atrial fibrillation.

may explain the absence of pulmonary edema in these cases. It is possible, however, that the high pulmonary "capillary" pressure was only temporary and due to anxiety during cardiac catheterization.

The comparison between the size of the left atrium, as judged by deviation of the esophagus, and the pulmonary "capillary" mean pressure, revealed that in many cases there was extremely high pulmonary "capillary" pressure with only mild esophageal displacement. This finding suggests that the "capillary" pressure depends also on factors other than retrograde stasis. Spasm of the pulmonary veins at the

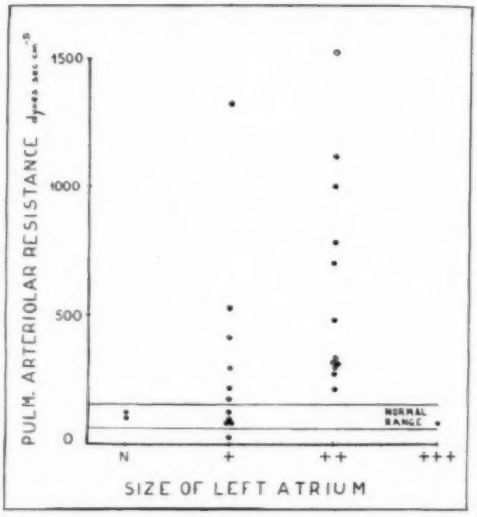


Fig. 15. Correlation between the size of the left atrium and the pulmonary arteriolar resistance. ○ indicates cases with atrial fibrillation.

veno-atrial junction has been shown to exist in man (2), and it is possible that this factor, which acts at a point proximal to the left atrium, is responsible for some increase of the pulmonary venous and, consequently, of the pulmonary "capillary" pressure. A further possibility is that the esophagus slips from the atrial summit as a result of excessive atrial enlargement, therefore giving the false impression of normal atrial size.

Our study showed that increase of the heart size was associated with a diminished cardiac index. This inverse relation between the heart size and the cardiac index is in accordance with the generally accepted concept.

## SUMMARY

Roentgen observations on the heart and lungs in 50 patients with mitral stenosis

were correlated with the hemodynamic data obtained by cardiac catheterization.

1. Moderate or marked enlargement of the pulmonary artery and the hilar markings was accompanied by elevated pulmonary artery mean pressure, and pulmonary vascular and arteriolar resistances. The tendency was to an inverse relation between these x-ray findings and the hemodynamic data.

2. The appearance of the peripheral lung fields did not correlate well with the pulmonary artery and "capillary" mean pressures and pulmonary arteriolar resistance. Normal peripheral lung fields were sometimes found in patients with severe pulmonary hypertension.

3. Moderate or marked enlargement of the heart was accompanied by increased pulmonary artery and right ventricular mean pressures and pulmonary vascular resistance. Increase in heart size was accompanied by a decrease of cardiac index.

4. Enlargement of the left atrium was always associated with elevated pulmonary "capillary" mean pressure. In a few instances mild enlargement of the left atrium was accompanied by extremely high pulmonary "capillary" mean pressure.

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SUMARIO

**Relación de los Hallazgos Radiográficos con la Hemodinámica en la Estenosis Mitral**

En 50 enfermos de estenosis mitral, se correlacionaron las observaciones roentgenológicas en el corazón y el pulmón con los datos hemodinámicos obtenidos con el cateterismo cardíaco.

1. El agrandamiento moderado o destacado de la arteria pulmonar y de las marcas hiliares se acompañó de elevación de la tensión media de la arteria y de resistencia vascular y arteriolar en el pulmón. La tendencia fué en razón inversa entre estos hallazgos radiográficos y los datos hemodinámicos.

2. El aspecto de los campos pulmonares periféricos no correlacionó bien con las tensiones medias en la arteria pulmonar y "capilares" y la resistencia arteriolar en el pulmón.

3. El agrandamiento moderado o destacado del corazón se acompañó de aumento de las tensiones medias de la arteria pulmonar y del ventrículo derecho y de la resistencia vascular en el pulmón. El aumento de tamaño del corazón se acompañó de disminución del índice cardíaco.

4. El agrandamiento de la aurícula izquierda se asoció siempre con elevación de la tensión media "capilar" en el pulmón. En algunos casos el agrandamiento ligero de la aurícula izquierda se acompañó de extraordinaria elevación de la tensión media "capilar" pulmonar.

# Localized Mesothelioma of the Pleura

## A Review with Six New Cases[1]

HENRY C. BLOUNT, JR., M.D.[2]

LOCALIZED mesothelioma of the pleura is a relatively rare tumor; a review of cases indicates, however, that this diagnosis can justifiably be made in the presence of certain roentgenologic findings. The condition was first established as an entity by Stout and Murray in 1942 (1). Since that time approximately 50 cases have been reported in the English literature (2–8).

Localized mesothelioma must not be confused with two other tumors, which are also referred to as mesothelioma: diffuse mesothelioma and mesothelioma of the male and female genital tracts. *Diffuse mesothelioma* is well known. It is a malignant neoplasm which invades locally, spreading widely over mesothelial surfaces, but rarely metastasizing to distant parts of the body. This tumor characteristically forms tubules lined by anaplastic cells. It most frequently arises from the peritoneum, though the pleura or pericardium may sometimes be the site of origin. *Mesothelioma of the male and female genital tracts*, unlike the diffuse and localized mesotheliomas of the pleura, pericardium, and peritoneum, tends to form small nodules composed of tubules lined by cells which secrete a mucoid substance. Most authors regard these tumors as of mesothelial origin, though some consider them adenomatoid tumors or true adenomas (2). Mesotheliomas of the genital tract are generally considered to be benign. Horn and Lewis (9), however, in a review of the literature indicate that 1 of 27 reported cases may have been malignant.

Until recently, all recorded cases of localized mesothelioma were considered to be of the fibrous type. Yesner and Hurwitz (8), however, reported a localized mesothelial tumor which they and the Armed Forces Institute of Pathology believed to be of epithelial type. For this reason the group of tumors to be described here will be referred to simply as localized mesothelioma, with recognition of the fact that both fibrous and epithelial types may exist.

### SYMPTOMS AND CLINICAL FINDINGS

Some cases of mesothelioma of the pleura have been entirely asymptomatic. In others, there have been slight symptoms, such as a mild cough and a feeling of heaviness and vague discomfort in the chest. Clagett *et al.* (4) observed that 7 of 24 patients gave histories of recurrent chills and fever. Dyspnea, weight loss, malaise, chest pain, etc., may be present, depending upon the size and location of the mass.

A report by Wierman, Clagett, and McDonald (10) indicates that localized pleural mesothelioma produces joint signs and symptoms, such as stiffness and pain and occasionally swelling and tenderness, in a higher percentage of cases than any other intrathoracic mass. In one series, 16 of 24 patients had symptoms and/or physical signs referable to the joints; 11 of these showed clubbing of digits (4). Another report (5) describes a striking degree of clubbing of the fingers with roentgen findings of hypertrophic pulmonary osteoarthropathy in 3 of 6 patients (5). The hands and ankles are more commonly affected, though other joints in the extremities may be involved (4). In a few instances the only symptoms have been those referable to the joints.

Pleural effusions, sometimes copious, occasionally occur with both benign and malignant localized mesotheliomas. Cell

[1] From the Edward Mallinckrodt Institute of Radiology, Washington University School of Medicine, Saint Louis, Mo. Presented at the Forty-first Annual Meeting of the Radiological Society of North America, Chicago, Ill., Dec. 11–16, 1955.

[2] Now at Frederick C. Smith Clinic, Marion, Ohio.

blocks from pleural fluid obtained in these cases have not been helpful in revealing the nature of the masses. Bloody pleural fluid was obtained in at least 1 instance (5).

While symptoms may be absent or of short duration, they have in some instances been present for several years, and in 1 case were reported to have lasted for sixteen years (4). They generally disappear following surgical removal of the tumor. Joint symptoms in particular may be dramatically relieved after operation.

The only previously reported localized mesothelioma of epithelial type produced no symptoms; it arose from the visceral pleura over the left lower lobe and was adherent also to the mediastinal pleura (8). The mass was firm, well encapsulated, and essentially epithelial in nature. The patient was asymptomatic, without evidence of recurrence, sixteen months after operation.

## PATHOLOGY

Most of the reported localized mesotheliomas arose from pleura, though a few had their origin from peritoneum. It seems reasonable to assume that they may also originate from pericardium. Well over half of the thoracic group were found to arise from visceral pleura. No sex predilection has been observed. The incidence is greatest after the age of forty, but the tumor has been found in persons as young as twelve years.

Growth of the neoplasms is relatively slow; they may reach a considerable size, in some instances measuring up to 36 cm. in greatest diameter and weighing as much as 5,000 gm. In a few of the large masses showing necrosis, small deposits of calcium were also observed.

Localized mesothelioma may be either benign or malignant, the incidence of cancer being undetermined because of the relatively small number of recorded cases. Among several small series the incidence was variously reported. Stout and Himadi found 5 of 8 cases to be malignant (3) and Clagett *et al.* 4 of 24 cases. On the other hand, none of the 6 cases reported by Benoit and Ackerman (5) showed malignant change.

Benoit and Ackerman have stated that the gross appearance of localized fibrous mesothelioma is sufficiently characteristic for its identification at operation. The benign fibrous tumors are well encapsulated; they may be nodular in appearance, and usually are quite firm, although some are soft or cystic in portions. They are, as a rule, quite vascular, with dilated veins often visible on their surfaces. They are usually attached by relatively narrow vascular pedicles, in addition to which there may be several adhesions about the mass.

Encapsulation of localized malignant fibrous mesotheliomas is less well defined than of the benign growths, and the former may invade adjacent tissues and spread beneath nearby mesothelial surfaces. The attachments of the malignant tumors are broader, with the masses sometimes buried in the chest wall, lung, mediastinum, abdominal wall, etc., depending upon the site of origin. Local recurrence may take place after operation, though metastasis is minimal. Benoit and Ackerman have found the prognosis following surgical removal of these recurrences to be favorable.

The histologic appearance of localized fibrous mesotheliomas varies considerably from one tumor to another and from area to area in the same tumor. Stout (2) has emphasized that these masses are easily recognized during microscopic examination, though because of the variability in appearance it is difficult to select an area as characteristic. Histologically, they have often been misdiagnosed as neurogenic and fibrous tumors and occasionally as smooth-muscle growths. In the benign fibrous type the cells resemble fibroblasts and there is an abundance of collagen and reticulin. In the malignant fibrous type the cells are more abundant and less well differentiated, with little, if any, collagen and reticulin. Necrotic areas are more commonly found in the large masses. The difference in the histologic appearance of benign and malignant fibrous mesotheliomas may be very clear, although in some

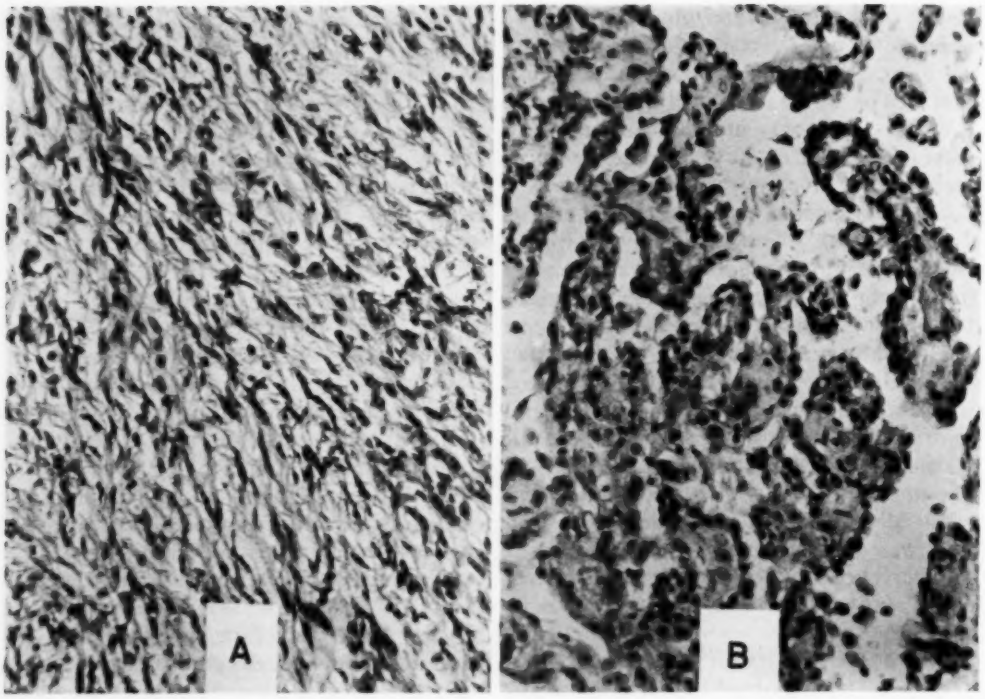


Fig. 1. A. Benign localized fibrous mesothelioma (× *c.* 160). Note the numerous well differentiated spindle cells interspersed with collagen. B. Benign localized epithelial mesothelioma (× *c.* 160), showing papillary projections, with fibrovascular stalks, covered with mesothelial cells not unlike epithelial cells in appearance.

instances a growth of benign appearance may prove to be malignant. Hill (11) reported a case of localized fibrous mesothelioma arising from peritoneum which appeared histologically to be benign but was shown by the clinical course to be malignant.

Histologic examination of a localized epithelial mesothelioma reported by Yesner and Hurwitz (8) showed the tumor to be of the papillary type. The papillary projections were composed of loose fibrous tissue covered by cuboidal cells which strongly resembled mesothelial cells. There was no basement membrane. Some small foci of necrosis were present.

Photomicrographs of a benign localized fibrous mesothelioma (Case IV) and a benign localized epithelial mesothelioma (Case VI) are reproduced in Figure 1.

### ROENTGENOGRAPHIC APPEARANCE

Localized mesotheliomas of the pleura may be seen roentgenologically at any visceral pleural site over the lung surface, or in any interlobar fissure, or at any parietal pleural site over the chest wall, mediastinum, or diaphragm. The masses are generally discretely outlined, the roentgenographic density being the same as of any other soft tissue with the exception of fat. The outline may be obscured partially or completely by a pleural effusion. Occasionally some lobulations may be evident.

Size is not particularly helpful in making the correct diagnosis of these tumors, except in some cases in which they become relatively large. Localized mesotheliomas at the surface of a lung, arising either from visceral or parietal pleura, often are elongated and roughly lenticular in outline, the surfaces toward the parietal area being relatively flatter than those adjacent to the lung. Tumors which occur within interlobar fissures also are often slightly elongated and roughly lenticular. A mass arising

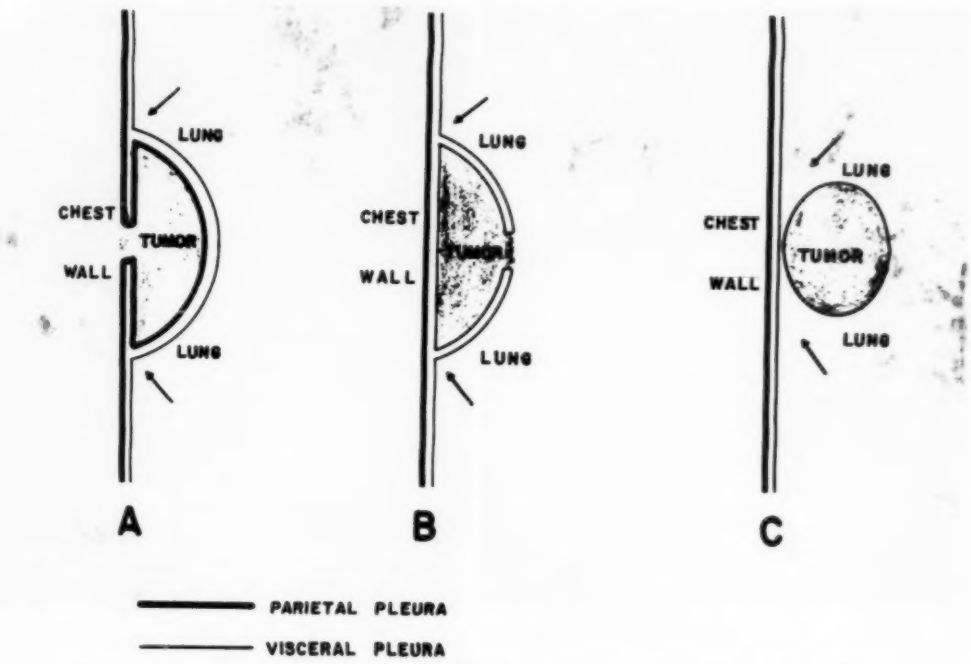


Fig. 2. Schematic representation of a tumor arising from parietal pleura or chest wall and projecting into the thorax (A), an extrapulmonary tumor arising from visceral pleura (B), and an intrapulmonary tumor at the surface of the lung (C). The angles formed in roentgenograms by the profile of the chest wall and a tumor arising from parietal pleura (A) may be the same as those formed by the chest wall and a tumor arising from visceral pleura (B). Compare with these the angles formed by the chest wall and an intrapulmonary tumor (C). Occasionally, an extrapulmonary tumor may have the roentgenographic appearance of an intrapulmonary mass at the surface of a lung (Fig. 5) and *vice versa*.

from pleura in an interlobar fissure may frequently be located by identification of the fissure at one or both ends. On the roentgenogram, localized mesotheliomas are occasionally misinterpreted as loculated collections of pleural fluid.

At the surface of the lung localized mesotheliomas usually have the roentgenographic appearance of extrapulmonary masses, regardless of whether they originate in visceral or parietal pleura (Fig. 2). Extrapulmonary masses, however, occasionally simulate peripheral intrapulmonary tumors (Fig. 5) and vice versa.

A mass having the roentgenographic appearance of an extrapulmonary tumor, yet actually arising from the visceral pleura, is occasionally seen fluoroscopically, or by multiple film technics, to move with the lung during respiration (Fig. 3). Similarly an intrathoracic tumor may be established as extrapulmonary and unattached to the lung by observation of the

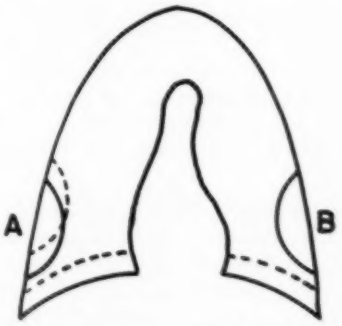


Fig. 3. Schematic representation of a mass with a profile suggestive of an extrapulmonary tumor but moving with the lung during respiration and therefore attached to the lung (A), and of a tumor with a similar profile, fixed to the chest wall and not moving with the lung during respiration (B).

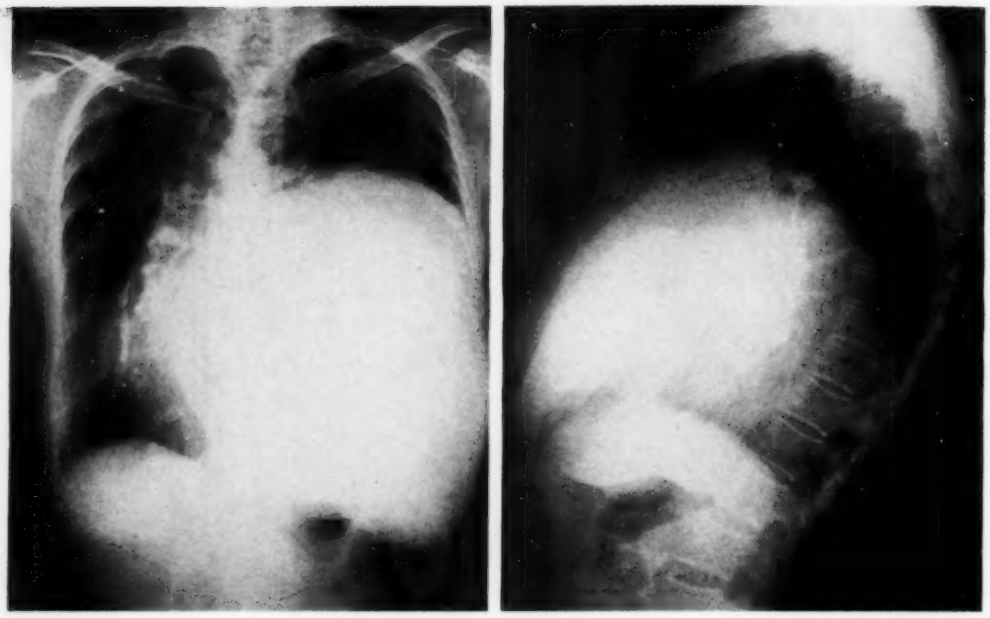

Fig. 4. Case I. Benign localized fibrous mesothelioma of pleura. Large mass arising from parietal pleura over left hemidiaphragm.

lung moving over the mass. In the presence of adhesions, however, motion of the lung over the mass, or of the latter during respiration, may not be observed. The introduction of air into the pleural space with appropriate roentgenographic studies may be very helpful in determining whether a mass is attached to the lung, chest wall, mediastinum, or diaphragm. In Case V the tumor could be seen fluoroscopically to move with the lung during respiration.

Occasionally, a slight alteration in outline of localized mesotheliomas is evident with deep inspiration and expiration. This is attributed to the fact that many of these neoplasms are attached by relatively narrow pedicles and their profiles, as seen roentgenographically, may show some change as a result of slight rotation of the masses on their axes. Such a change was observed in Case V.

Because of the relatively high incidence of hypertrophic pulmonary osteoarthropathy in these cases, it is probably wise to obtain survey roentgenograms of several long bones in cases in which the diagnosis of localized mesothelioma of pleura is being considered.

## CASE REPORTS

CASE I: E. G., a 57-year-old white female, first entered Barnes Hospital on Sept. 12, 1953, complaining of aching chest pain of three months duration. Eight months prior to admission a clinical diagnosis of pneumonia was made but no roentgenograms were obtained. Response to therapy was satisfactory. During the five months before admission the patient had experienced gradually increasing exertional dyspnea. Anorexia and a fairly constant aching pain in the left lower hemithorax anteriorly developed three months prior to admission. There had been a weight loss of approximately 10 pounds.

Physical examination revealed dullness with decrease or absence of breath sounds in the lower two-thirds of the left hemithorax. There were indications also of a mediastinal shift to the right. No other significant abnormality was observed.

Roentgenograms of the chest revealed a large mass in the left hemithorax, with displacement of the mediastinal structures to the right. Red blood count, hemoglobin, white blood count, and urinalysis were all within normal limits.

The patient was discharged on Sept. 15 and re-

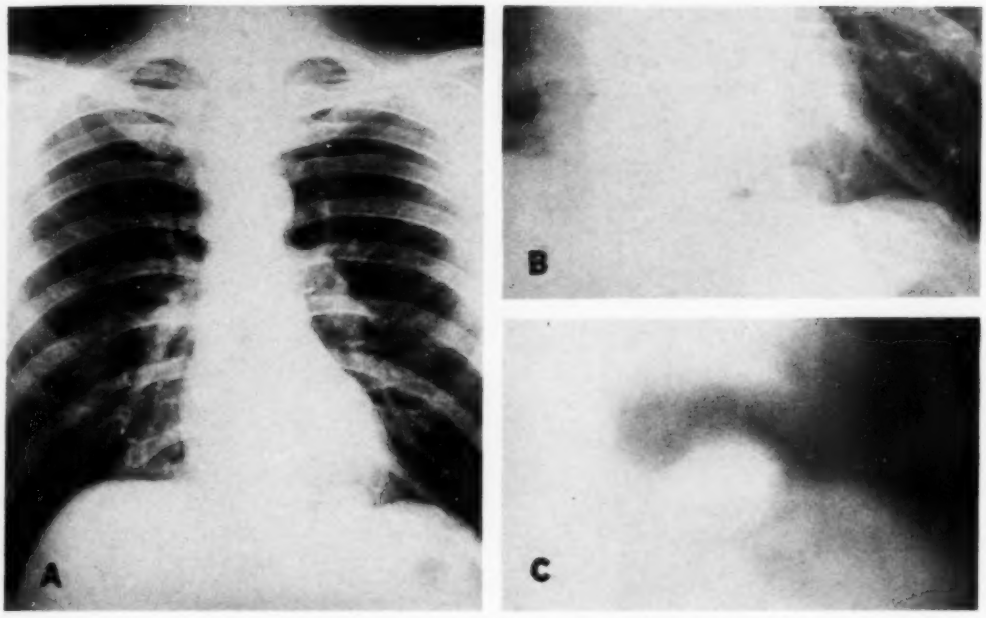


Fig. 5. Case II. A. The mass is visible through the cardiac shadow in the area of the left hemidiaphragm. B. Enlargement of the area of the tumor. C. Body-section roentgenogram showing zone of lesser tissue density about the mass. This was interpreted as evidence that the tumor was separate from the diaphragm. It proved, however, to be a benign localized fibrous mesothelioma arising from diaphragmatic pleura.

admitted six days later. Tissue obtained by needle biopsy was interpreted as being neurogenic in origin, but no definite diagnosis was made. On Sept. 25 the tumor was removed. It was found to be attached to the diaphragm, projecting into the left pleural space and filling slightly more than half of the left hemithorax. During the surgical procedure there was a drop in blood pressure, and it remained lower during the postoperative period than it had been preoperatively. The course was satisfactory, and the patient was discharged on the twelfth postoperative day.

The tumor measured 20 × 15 × 15 cm. in greatest dimensions. The surface was smooth, and the mass white to yellow-white in color. The site of the diaphragmatic attachment measured 6 × 3 cm. in greatest dimensions. Except for a few cystic areas, filled with clear mucoid fluid, the tumor was of firm consistency. Interlacing bands of tissue were grossly visible on the cut surfaces.

The predominant histologic feature was the presence of spindle cells and abundant interlacing bands of fibrous tissue, with mature collagen in some areas. No necrotic areas were observed in the sections taken for histological study. *Pathological diagnosis:* Benign localized fibrous mesothelioma of pleura.

The patient was asymptomatic, and without evidence of recurrent or metastatic tumor, twenty-six months after the operation.

CASE II: E. S., a 47-year-old white man, was admitted to Barnes Hospital on April 20, 1953. He was without symptoms but an intrathoracic mass had been discovered in a roentgenographic survey examination of the chest. The only abnormal physical finding was an apical systolic murmur. Laboratory studies, including white blood count, red blood count, hemoglobin, urine examination, and examination of a stool specimen, were all within normal limits. The patient was discharged after three days to return at a later date for operation. He was readmitted on Aug. 20, still asymptomatic, and the tumor was removed the following day. The postoperative course was satisfactory.

At operation, the tumor was found to be well encapsulated and attached to the left hemidiaphragm by a narrow pedicle, with no evidence of subpleural extension. It was firm and of gray color, roughly ovoid in shape, measuring 4 × 3 × 3 cm. in its greatest dimensions. The cut surface was lobular, with strands of tissue arranged in whorls. Histologic study showed the tumor to consist largely of spindle cells separated by bundles of collagen; there were also some irregular spaces lined by cuboidal epithelium. *Pathological diagnosis:* Benign localized fibrous mesothelioma of pleura.

Thirty months after operation the patient was asymptomatic and without evidence of recurrent or metastatic tumor.

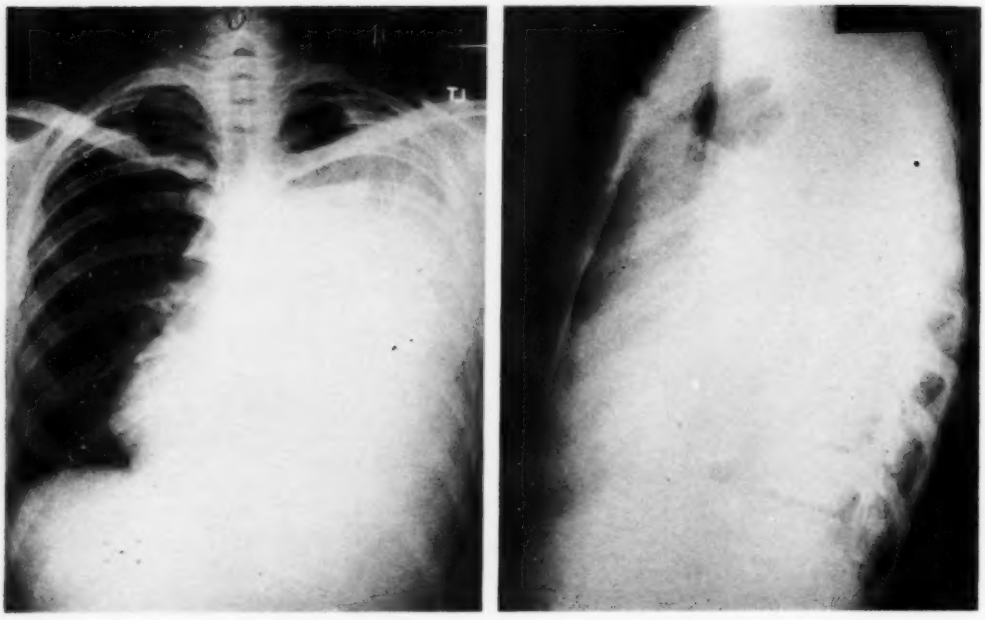

Fig. 6. Case III. Benign localized fibrous mesothelioma arising from mediastinal pleura. The presence of pleural fluid obscures the outline of the large mass in the left hemithorax.

CASE III: F. F., a 24-year-old white male, was admitted to Barnes Hospital on April 27, 1952, with a history of removal of bloody fluid from the left chest on several earlier occasions. Symptoms first occurred twenty-one days before admission, when in about a half-hour period the patient experienced increasingly severe left chest pain, which became worse with respiration. About nineteen days before admission a "quart" of fluid having the appearance of "pure blood" was removed from the left hemithorax and found to contain two million red blood cells per cubic millimeter. During the next few days several additional thoracenteses were performed, "several ounces" of bloody fluid being removed in each instance.

In the few days preceding admission the patient's temperature rose intermittently to as high as 101° F. A non-productive cough, aggravated by a change in position, was also present. In a period of three weeks there had been a weight loss of approximately 30 pounds.

The patient was weak and appeared to be chronically ill. Significant physical findings were confined to the chest. There was dullness over the left chest except for the extreme apex; breath sounds were diminished or absent on the left side, also with the exception of the apex.

The red blood count was 3,750,000, with a hemoglobin of 10.3 grams. Shortly after admission, pleural fluid was found to contain *Staphylococcus albus*. Studies of sputa, gastric washings, and pleural fluid were negative for *Mycobacterium tuberculosis*. Antimicrobial medication was instituted at once.

At operation, on the eighth hospital day, some free fluid and a large cystic mass were removed from the left hemithorax. Although the major portion of the mass lay in the lower left hemithorax, the pedicle was attached just under the subclavian vein. The growth was estimated to be approximately 25 cm. in greatest dimension. During the operation it was opened and a large portion of the contents was evacuated. Small amounts of fluid were removed from the left hemithorax on several occasions in the immediate postoperative period. The course was satisfactory and the patient was discharged on the thirteenth postoperative day.

Grossly the tumor was well encapsulated and soft, weighing 1,240 grams. After removal, it measured 19 × 14 × 7 cm. in greatest dimensions. It was largely whitish in color, with several necrotic areas which contained a gelatinous material varying from pink to deep red in color.

Histologic study revealed an excessive proliferation of fibrous tissue with no particular pattern. Some chronic inflammatory cells were present and there were also areas of necrosis and some small foci of calcification.

*Pathological diagnosis:* Benign localized fibrous mesothelioma of pleura.

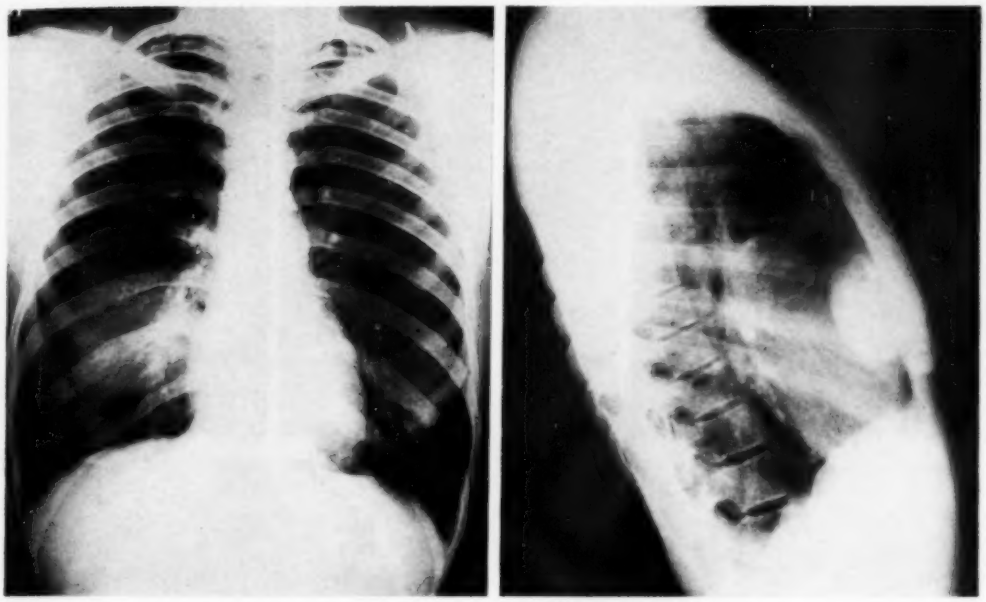

Fig. 7. Case IV. Benign localized fibrous mesothelioma arising from visceral pleura over the inferior anterior surface of the upper lobe of the right lung. The roentgenographic appearance is not unlike that often observed in masses arising in the chest wall and projecting into the thorax.

CASE IV: R. T., a 25-year-old white woman, entered Barnes Hospital on Sept. 8, 1952. Six weeks earlier a survey photofluorogram disclosed evidence of an intrathoracic mass. Two years before admission, a roentgenographic examination of the chest had been reported normal. For several years the patient had had a slight cough and had suffered occasional asthmatic attacks. For about one year she had experienced occasional vague discomfort in the lower portion of the right hemithorax. There were no other symptoms. The only significant finding on physical examination was a slight wheeze, present both in inspiration and expiration.

On admission, red blood count, white blood count, and hemoglobin were within normal limits. Routine examination of the urine revealed no abnormality. Roentgenograms were interpreted as showing a tumor of the anterior thoracic wall on the right.

The tumor was removed on the second hospital day. The course was satisfactory and the patient was discharged nine days postoperatively.

The growth was attached by a pedicle to the inferior anterior portion of the right upper lobe. It was well encapsulated, quite firm, and roughly lenticular in shape, measuring $8 \times 8 \times 3$ cm. in its greatest dimensions. On the cut surface were multiple yellowish-white lobules with evidence of old hemorrhage between some of them.

Histologically the tumor was rather homogeneous, being composed almost entirely of spindle cells and collagen fibers arranged in linear strands and whorls. Numerous blood vessels were present throughout, with some areas of recent hemorrhage. *Pathological diagnosis:* Benign localized fibrous mesothelioma of pleura.

Three years after operation the patient was free of symptoms, with no evidence of recurrent or metastatic tumor.

CASE V: D. C., a 48-year-old white man, was admitted to the Public Health Service Hospital in Seattle, Wash., on Feb. 25, 1954. Five weeks prior to that time he had been hospitalized elsewhere because of fever and malaise of several days duration. At that time roentgenograms revealed evidence of a mass in the posterior inferior portion of the left hemithorax. Two attempts to obtain fluid from the tumor region by needle aspiration failed. After a few days of antimicrobial therapy the patient was considerably improved and was discharged.

On admission to the Public Health Service Hospital, he gave a history of slight weakness for several weeks, stiffness and aching pain in both knees for about five weeks, and slight stiffness of both wrists for a few days. The aching in the joints was more severe with motion. On closing the hand into a fist, the skin appeared tighter than usual. There had been a weight loss of 10 pounds in the six weeks prior to admission. At no time during the present illness were there any symptoms referable to the chest.

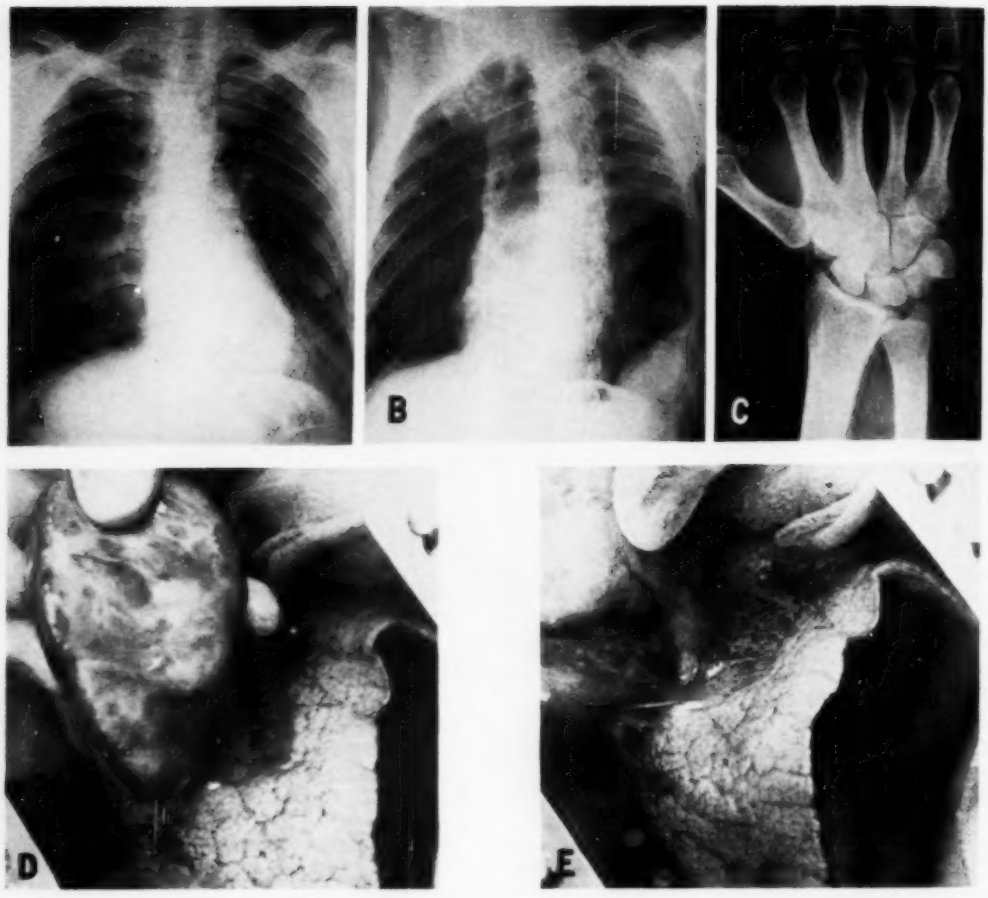


Fig. 8. Case V. Benign localized fibrous mesothelioma arising from visceral pleura over the lower lobe of the left lung. A and B. Mass in the posterior inferior portion of the left hemithorax. The roentgenographic appearance is not unlike that often observed in masses which arise in the chest wall and project into the thorax. C. Periosteal new bone formation visible along the shafts of the long bones. D. Retraction of the mass away from the lung. E. Specimen showing narrow pedicle and some adhesions.

Abnormal physical findings were limited to slight dullness over the posterior inferior portion of the left hemithorax and moderate swelling of the hands. Routine laboratory studies of blood and urine disclosed only a slight anemia.

Roentgenograms showed a mass in the chest, in the posterior inferior portion, regarded at first as either a loculated effusion or a tumor arising from the thoracic wall. On fluoroscopy, however, the mass was observed to move with the left lung during respiration and was therefore considered to have a pulmonary origin. A slight difference in outline was observed in roentgenograms exposed during inspiration and expiration, probably attributable to a minor change in the axis of the tumor. Roentgenograms of the extremities revealed periosteal new-bone formation along the shafts of all the major long bones, this being most striking along the distal portions of the radii and ulnae. A review of roentgenograms made six weeks earlier showed that there had been no change in size or shape of the mass in the interval.

On the nineteenth hospital day the growth was removed, with subsequent dramatic relief of all joint symptoms. The postoperative course was satisfactory and the patient was discharged on the eighteenth day. Roentgenograms of the wrists obtained six weeks postoperatively revealed a definite decrease in the amount of periosteal new bone along the shafts of the ulnae and radii.

The tumor was attached to the lower lobe of the left lung by a narrow but quite vascular pedicle. It was well encapsulated and firm, measuring 11 × 7 × 5 cm. in greatest dimensions. On the cut surface a small area of necrosis in the central portion was

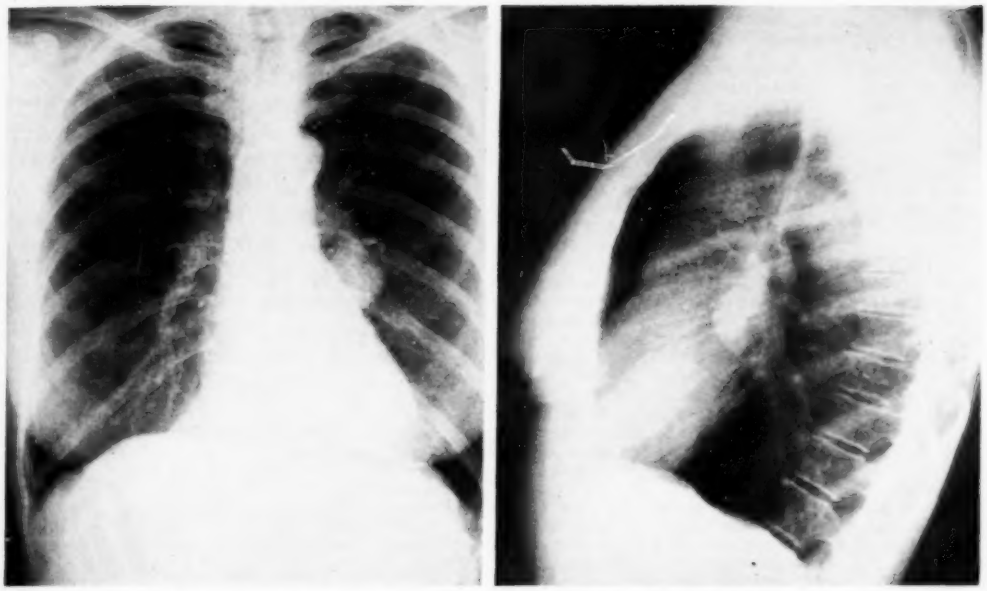

Fig. 9. Case VI Benign localized epithelial mesothelioma arising from the interlobar pleura of the upper lobe of the left lung. The mass appears as a "coin lesion" in the lung near the left hilus.

identified. Grossly, there were lobules in the mass, with some whorls of tissue. Histologic examination revealed the presence of spindle cells with collagen in many areas; vascular channels were prominent. *Pathological diagnosis:* Benign localized fibrous mesothelioma of the pleura.

Seven months after operation the patient was free of symptoms, with no evidence of recurrence or metastasis.

CASE VI: E. K., a 65-year-old white female, entered Barnes Hospital on April 4, 1955, complaining of upper abdominal pain, becoming worse after meals and occasionally cramping. This had been present for about three weeks, and during the same period she had experienced nausea and vomiting, diarrhea, and chilly sensations. No symptoms referable to the chest were mentioned. For the past thirty-two years the patient had suffered recurring pain in the wrists, hands, and shoulders. In the eight years prior to admission, there had been slight swelling and stiffness of the joints of the upper extremities, particularly noticeable in cold, damp weather.

The only significant physical finding was slight tenderness in the upper abdomen bilaterally. Routine blood and urine studies were normal. A stool sample gave a 2+ benzidine reaction. An electrocardiogram was normal. The sole roentgen finding of importance, in studies of the chest, gallbladder, gastrointestinal tract, and urinary system, was an almost spherical mass, measuring approximately 4 cm. in diameter, in the region of the lingular division of the left upper lobe.

The abdominal symptoms subsided after a few days, and on April 14 the intrathoracic tumor was removed. It was found to be in the lingular division of the left upper lobe, adjacent to the fissure between the upper and lower lobes. The tumor was well encapsulated, and "shelled out" without difficulty. No definite pedicle was demonstrated. A frozen section was reported as "papillary tumor, probably benign." Removal of the left upper lobe was then performed. The subsequent course was satisfactory, and the patient was discharged on the tenth postoperative day.

Grossly, the tumor was firm and roughly spherical, measuring 4 × 3 × 3 cm. in greatest dimensions. It was surrounded by an intact capsule. On cut surface, the tissue was a mottled yellowish-white in color and rather friable. Histologically, the predominant feature was the presence of many papillary projections, with a loose, myxomatoid stroma and scattered collections of lymphocytes and plasma cells. The papillary projections took the form of fibrotic and rather vascular stalks covered by mesothelial cells with an appearance not unlike epithelial cells. *Pathological diagnosis:* Localized epithelial mesothelioma of pleura.

Four months after operation the patient's condition was good, with no evidence of recurrent or metastatic tumor.

## DISCUSSION OF CASES

Of the 6 cases of localized mesothelioma of pleura presented here, 5 were of the

TABLE I: SIX CASES OF LOCALIZED MESOTHELIOMA OF THE PLEURA

| | Sex and Age | Symptoms and Clinical Findings | Roentgenographic Appearance | Origin of Mass | Size in Centimeters | Type of Localized Mesothelioma |
|---|---|---|---|---|---|---|
| Case I E. G. | F 57 | Chills and fever 8 mo. before operation. Exertional dyspnea for 5 mo. Aching in left chest for 3 mo. 10-pound weight loss. | Large mass in left hemithorax. | Parietal pleura over left hemidiaphragm. | 20 × 15 × 15 | Benign fibrous |
| Case II E. S. | M 47 | No symptoms. | "Coin lesion" just above left hemidiaphragm. | Parietal pleura over left hemidiaphragm. | 4 × 3 × 3 | Benign fibrous |
| Case III F. F. | M 24 | Signs and symptoms of massive pleural effusion 3 weeks before operation. Bloody pleural fluid. | Massive pleural effusion on left. | Parietal pleura over mediastinum on the left. | 19 × 14 × 7 | Benign fibrous |
| Case IV R. T. | F 25 | Asthma for several years. | Extrapulmonary mass at surface of lung. | Visceral pleura over inferior and anterior portion of right upper lobe. | 8 × 8 × 3 | Benign fibrous |
| Case V D. C. | M 48 | Pain and stiffness of knees and hands. Slight anemia. | Extrapulmonary mass at surface of lung. | Visceral pleura over posterolateral portion of left lower lobe. | 11 × 7 × 5 | Benign fibrous |
| Case VI E. K. | F 65 | No chest symptoms. Long standing symptoms due to arthritis. Gallbladder symptoms. | "Coin lesion" near left hilus. | Visceral pleura of left upper lobe in interlobar fissure. | 4 × 3 × 3 | Benign epithelial |

fibrous type and 1 epithelial. Three arose from visceral pleura, 2 from the pleura over the lung surface, and 1 from the pleura in an interlobar fissure. Of the 3 from the parietal area, 2 originated from the diaphragmatic pleura and 1 from mediastinal pleura. The age range in this series was from twenty-four to sixty-five years. Three of the tumors occurred in males, and 3 in females. The smallest tumor measured 4 × 3 × 3 cm. in greatest dimensions, the largest 20 × 15 × 15 cm. (Table I).

One of these 6 patients had no symptoms, and 2 others had no symptoms referable to the chest. One of these latter complained of joint stiffness and pain, and the other was admitted to the hospital with symptoms which, even in retrospect, are considered to be due to gallbladder disease. Three patients had chest symptoms. One of these complained only of vague discomfort, which had been related to asthmatic attacks. Another, with a rather large intrathoracic mass, bloody pleural effusion, and displacement of mediastinal structures to the opposite side was asymptomatic until shortly before discovery of the bloody fluid in the left hemithorax. The third patient gave a history of exertional dyspnea and chest pain and some weight loss. In this last case the mass was rather large, causing displacement of mediastinal structures as well as compression of the adjacent lung.

The roentgen picture in 2 cases was that of a "coin lesion," located in 1 instance near the left hilus, with its origin from interlobar pleura, and in the other situated just above the surface of the left half of the diaphragm, arising from diaphragmatic pleura. Both localized mesotheliomas which arose from a lung surface had the roentgenographic appearance of chest wall tumors, and were regarded as such on the basis of the original roentgenograms, although one was subsequently found to be attached to the lung, with which it moved during respiration. The tumor arising from mediastinal pleura was rather large, appearing roentgenographically in the left hemithorax, with compression of a large portion of the left lung and displacement of mediastinal structures to the opposite

side. The remaining tumor was associated with a bloody pleural effusion, and the roentgen appearance was that of a massive pleural effusion on the left side, with little aeration of the left lung, and displacement of mediastinal structures to the right. In this case the outline of the mass was obscured by the pleural fluid. Only 1 of these patients had joint symptoms considered to be related to the tumor, and in this case hypertrophic pulmonary osteoarthropathy was evident roentgenographically. Roentgenograms of long bones were not obtained in the other cases.

## SUMMARY

The literature on localized mesothelioma of the pleura is briefly reviewed and 6 new cases are presented. The symptoms and histologic and roentgenographic findings are described. With alertness to the possibility of this condition, and by careful correlation of the clinical and roentgenologic observations, the radiologist may be able to make a correct diagnosis in some instances.

ACKNOWLEDGMENTS: Dr. Lauren V. Ackerman reviewed the cases presented and made many helpful suggestions in the preparation of this paper. Dr. Thomas Burford made available the records in the Thoracic Surgery Department. Permission to use Case V was granted by Dr. Theodore Perrin and Dr. Paul Walker.

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## SUMARIO

### Mesotelioma Localizado de la Pleura. Repaso con Seis Casos Nuevos

Repasada sucintamente la literatura relativa al mesotelioma localizado de la pleura, preséntanse 6 casos nuevos.

Los síntomas son generalmente leves o faltan, pero pueden volverse relativamente graves a consecuencia del desplazamiento y de la compresión de tejidos intratorácicos por el tumor en desarrollo. En un porcentaje relativamente alto de estos casos aparecen síntomas o signos físicos imputables a las articulaciones. Unidos a los tumores, pueden descubrirse derrames pleurales, a veces sanguinolentos. Los síntomas desaparecen generalmente después de la extirpación de la neoplasia.

Los mesoteliomas localizados benignos están bien encapsulados, teniendo casi siempre pedículos algo estrechos. Los malignos no suelen encapsularse tan bien, y los pedículos son generalmente más anchos; los tumores tienden a esparcirse debajo de las caras adyacentes del mesotelio, invadiendo localmente y formando pocas metástasis.

Histológicamente, el aspecto del mesotelioma fibroso localizado varía considerablemente. En la forma benigna, las células imitan en apariencia a los fibroblastos y hay reticulina y colágeno en abundancia. En la maligna, las células abundan más y están menos bien diferenciadas, habiendo muy poco colágeno y reticulina, si los hay. La diferenciación entre las tumefacciones benignas y malignas, a base del aspecto

macroscópico e histológico, resulta algunas veces difícil.

Radiográficamente, pueden observarse estas neoplasias en la región de cualquier superficie pleural. En contorno, tienden a ser lenticulares. Las que aparecen en la superficie de un pulmón tienen generalmente el aspecto de tumores extrapulmonares; cabe determinar el sitio de la inserción observando si el tumor se mueve con el pulmón o si el pulmón se mueve sobre el tumor durante la respiración. Los diagnósticos roentgenológicos más frecuentes en estos casos han sido derrame locular y tumor de la pared torácica, del mediastino o del diafragma. En los casos de mesotelioma localizado de la pleura, obsérvase con relativa frecuencia osteoartropatía pulmonar hipertrófica.

Estando a la mira de la posibilidad de esta dolencia, y con la cuidadosa correlación de los hallazgos clínicos y roentgenológicos, el radiólogo tal vez pueda hacer un diagnóstico acertado en algunos casos.

# Cholangiography by the Biligrafin Method With or Without Preceding Oral Cholecystography

## An Attempt to Assess the Reliability of the Biligrafin Method[1]

POVL HJORTH, M.D.

SINCE 1953, WHEN Schering published the first reports of an intravenous opaque medium for visualizing the biliary tract, later known as Biligrafin, numerous papers on this subject have appeared. Pharmacological-experimental (4, 10) as well as clinical studies came first from Germany (5, 7, 8, 14, 15) and then from other parts of the world, including the Scandinavian countries and America (1–3, 6, 9, 11–13, 16–20), establishing the Biligrafin method as an important advance in radiography of the biliary tract.

The present investigation was undertaken in a endeavor to assess the reliability and value of the procedure when combined with oral cholecystography.

### MATERIAL

From November 1953 to January 1955, 270 cholangiographic studies with Biligrafin were performed in the Department of Radiology of the Copenhagen Municipal Hospital. In 237 cases there had been failure to visualize the gallbladder by oral cholecystography, and in 33 cases the intravenous method was used primarily in previously cholecystectomized patients. It gradually became apparent that Biligrafin did not visualize the biliary tree at plasma values over 20 (Meulengracht), and during the latter part of the investigation Biligrafin was not used in such cases. Thus, in agreement with the reports of others, the upper limit of the plasma value was the same as that in ordinary oral cholecystography.

### TECHNIC

Preliminary *oral* cholecystography was performed after thorough preparation, *i.e.*, a fat-free diet and careful evacuation of the bowel; if necessary, a tannin enema (2.5 per cent) was given. On the first day the patients received Pheniodol. If visualization of the gallbladder was unsuccessful, Teridax was administered under the same conditions that evening, and another x-ray examination was performed the following morning. (In some instances Teridax was given on both days, but this proved of no advantage, since in the presence of a nonfunctioning gallbladder unabsorbed Teridax was so distinctly visible in the intestine as to disturb further examination by Biligrafin.) If the second examination also produced only a faint shadow of the gallbladder, or none at all, Biligrafin was administered.

All patients received a test dose of Biligrafin, 1 ml. intravenously. If there was no reaction at the end of twenty minutes, a full dose of Biligrafin (20 ml. × 2) was injected in the course of about ten minutes.

In 9 cases there were reactions to the test dose, as follows.

| | |
|---|---|
| Nausea and vomiting | 1 case |
| Sneezing and nasal discharge | 1 case |
| Itching, urticaria | 7 cases |

Eighteen patients who tolerated the test dose reacted to the higher dose, as follows:

| | |
|---|---|
| Itching and sneezing | 2 cases |
| Urticarial skin lesions (ten to thirty minutes after the injection) | 6 cases |
| Pain in the cubital vein during injection | 1 case |
| Severe nausea and vomiting, necessitating interruption of the injection | 9 cases |

In 1 instance in this last group of 9 cases the examination could not be carried through, as the dose injected was too low (less than 5 ml.); of the remaining 8 patients, none of whom received a complete dose, 5 were given more than 20 ml., 2 be-

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tween 10 and 20 ml., and 1 between 5 and 10 ml. In all 8, good filling of the gallbladder was achieved, corresponding to that observed with the usual dose.

Side-effects were thus observed in 27 cases, in 10 of which (3 per cent of the entire series) they prevented completion of the examination. Other workers (14, 19) have reported the incidence of disagreeable side-effects as about 4 per cent.

### X-RAY FINDINGS

According to the results, the series may be grouped as follows:

(1) Normal common duct. Distinctly visible, apparently normal gallbladder (21 cases).

(2) Normal common duct. Gallbladder not visualized (139 cases).

(3) Dilatation of common duct (41 cases).

(4) No visible excretion (51 cases).

(5) Technical failure, caused by unrest during examination; insufficient evacuation of the bowel prior to examination (8 cases).

(6) Examination prevented by side-effects (10 cases).

In only the first 4 groups may the reliability of the method be assessed.

*Group 1* (normal common duct; gallbladder distinctly visible and apparently normal): This group of 21 cases does not include any case submitted to operation after cholangiography with Biligrafin. Whether these gallbladders, which were not visualized by oral media but by Biligrafin only, are really normal appears doubtful. When the gallbladder fills following injection of Biligrafin, there can hardly be any mechanical obstruction to its entrance. Non-visualization upon oral cholecystography in these cases presumably indicates a pathological condition of the wall of the gallbladder which compromises its concentrating power, without preventing the entrance of Biligrafin. Strangely, in none of these cases were filling defects due to stones exhibited. Two of the patients had previously undergone cholecystotomy with removal of stones. In 2 more, oral cholecystography performed during a previous hospitalization had demonstrated calculi within the gallbladder, but in neither instance was surgery undertaken. The contrast afforded by Biligrafin is intense, perhaps so intense as to prevent the demonstration of small stones.

*Group 2* (normal common duct; gallbladder not visualized): This group of 139 cases includes 10 in which surgery was done. In all of these, the operation revealed a common duct of normal caliber with no obstruction to the flow of bile. In 2 instances, stones of pinhead size, not visible on the films, were removed from the common duct. These may have been pushed down into the duct during the mobilization of the gallbladder, which contained numerous calculi, also small. Incidentally, primary calculi of the common duct, of this size, probably cannot be directly visualized, being demonstrable only indirectly when blocking the duct.

The condition of the gallbladder in these cases will be discussed in more detail in connection with findings in the operative cases of the next group.

*Group 3* (dilatation of common duct): Of the 41 patients showing an abnormal common duct upon administration of Biligrafin, 22 were submitted to operation. The x-ray and operative findings are tabulated below.

| X-ray Findings | Operative Findings |
|---|---|
| Choledocholithiasis and dilatation of common duct: 12 cases | Choledocholithiasis and dilatation of common duct: 11 cases<br>Dilatation of common duct: 1 case |
| Dilatation of common duct (? choledocholithiasis): 5 cases | Choledocholithiasis and dilatation of common duct: 5 cases |
| Dilatation of common duct: 5 cases | Choledocholithiasis and dilatation of common duct: 2 cases<br>Dilatation of common duct: 2 cases<br>Normal common duct: 1 case |

In 21 of the 22 cases in which a pathological condition of the common duct was

diagnosed roentgenographically, the findings were confirmed by operation. In the single case in which the x-ray and operative findings were inconsistent, eleven days had elapsed between cholangiography by Biligrafin and surgery.

Of the 180 cases of *Groups 2 and 3*, 32 were submitted to operation. Six patients had previously undergone cholecystectomy, so that only the remaining 26 may be considered in assessment of the gallbladder findings. In 19 instances, the gallbladder was not visualized, while in 7 it showed up fairly well.

Among the 19 cases of non-visualization, subsequent operation disclosed a calculus of the cystic duct with pronounced dilatation of the gallbladder in 1. In 13, sequelae of chronic cholecystitis were apparent, with inflammatory changes of the gallbladder with or without calculi. In the 5 remaining cases operation revealed concretions but no marked changes. Whether these concretions hindered the filling with Biligrafin by obstructing the cystic duct at the time of the examination is uncertain, but this possibility cannot be dismissed.

In the 7 cases in which a gallbladder with calculi was visualized, operation revealed the (large) calculi shown on the films, with no changes which might prevent the entrance of Biligrafin. In 1 instance, in which the contrast had been rather faint, the wall of the gallbladder was considerably thickened, but its lumen was free.

*Group 4* (no visible excretion): In 51 cases, no opaque medium was visible in the gallbladder, deep biliary tract, or small intestine. In other series, similar findings have been described. No definite explanation for this has been advanced. Some workers have attributed it to parenchymal hepatic disease, while others have merely stated that visualization is not achieved at distinctly elevated plasma values; as already mentioned, visible excretion was not obtained in any of the present cases with plasma values in excess of 20.

In 11 of this group of cases the plasma values were over 20. In 4 of these, in which the plasma values ranged from 40 to 150, the final clinical diagnosis was hepatitis. No mass was palpable at the site of the gallbladder and on the whole there was no sign of cholecystitis. One of these patients, brought to surgery because of suspected occlusion, proved to be suffering from hepatic cirrhosis. In the remaining patients, there were no clinical signs of parenchymal liver disease. In 1, surgery disclosed pronounced stasis in the biliary tract, a calculus in the common duct, and a dilated highly inflamed gallbladder with calculi.

In 40 cases, there was no visible excretion despite plasma values below 20. The plasma values in these cases were practically normal. Clinical signs of acute cholecystitis were present in 24, with a considerably enhanced erythrocyte sedimentation rate, an elevated temperature, and a palpable mass or marked tenderness at the site of the gallbladder. Five of this group had previously undergone cholecystectomy and all showed signs of cholangitis which had given rise to recurrent attacks of fever. In the 11 remaining patients there were no clinical signs of cholecystitis or cholangitis.

Of the 24 patients with clinical signs of cholecystitis at the time of the x-ray examination, 11 were subsequently submitted to operation. In this group, the surgical and pathologic findings, gross and microscopic, were severe inflammatory changes of the gallbladder with obliteration of its lumen, or obstruction of the *cystic duct* either by a kink caused by adhesions or a wedged-in calculus. *In only 1 instance did operation reveal signs of stasis in the deep biliary tract resulting from calculi in the common duct.* In the other cases the common duct was normal.

None of the 5 previously cholecystectomized patients showing clinical signs of cholangitis was submitted to re-operation after the Biligrafin examination.

Of the 11 patients without clinical signs of cholecystitis or cholangitis 5 underwent operation. Two non-operated cases proved fatal. Cancer of the pancreas with

pronounced stasis of the deep biliary tract was found at autopsy in 1, while severe cirrhosis of the liver with periportal fibrosis and pronounced ascites was seen in the other.

In 3 instances operation revealed marked inflammatory changes of the gallbladder, causing obliteration of its lumen or obstruction due to kinking of the cystic duct. Two cases showed pronounced dilatation of the gallbladder, with calculi wedged in the cystic duct. Stricture of the common duct was observed in 1 case, while in 4 the duct was normal.

*Hence, the absence of visible excretion was found to be due to gallbladder changes alone in 14 out of 16 operated cases.*

## DISCUSSION AND CONCLUSION

The results of cholangiography with Biligrafin in a series of 270 cases are reported (237 in which oral cholecystography had failed and 33 cholecystectomized patients). The operative findings as to the condition of the common duct were consistent with the roentgen studies in 21 of 22 cases. The width of the common duct was estimated on the basis of the patient's size and body thickness, with due regard to the consequent difference in the focus-film distance. Measurement of the exact width of the duct was not undertaken, since the sources of error involved in definition of the normal range are believed to be too great. In cases of previous cholecystectomy, and choledocholithotomy in particular, we have been most conservative in attributing pathological significance to moderate dilatation of the common duct, especially when the presence of opaque medium in the small intestine after the examination affords further proof of patency.

By similar analyses other workers have shown that Biligrafin will visualize the deep biliary tract only in a certain proportion of cases. Owing to the varying bases for selection in these series, however, a comparison of the percentages is of no value.

Our findings suggest that failure to visualize the gallbladder at the same time that successful visualization of the biliary ducts is achieved following injection of Biligrafin indicates severe changes of the gallbladder, cystic duct, or both, with mechanical obstruction to the entrance of the opaque medium.

In a number of cases, non-visualization of the gallbladder by an oral opaque medium has been followed by distinct visualization by Biligrafin. Hence, the oral method must be assumed to afford more information regarding the function of the gallbladder than intravenous cholangiography with Biligrafin, which does not yield any data about the concentrating power of the organ. When used alone, the Biligrafin method may veil morbid conditions of the gallbladder. In our Department, therefore, we shall continue the use of routine oral cholecystography prior to cholangiography with Biligrafin.

In the great majority of the present series in which there was no visible excretion of Biligrafin, the plasma values and liver function tests were normal; these cases must therefore be classified as cholecystitis-cholangitis. In only a small group, 5 of 51 cases, did liver-function tests and surgical and autopsy findings establish the diagnosis of parenchymal liver disease.

Despite the greatly improved chances of assessing the condition of the biliary tract afforded by Biligrafin cholangiography the difficulty of distinguishing between a primary lesion of the hepatic parenchyma and biliary tract disease still exists. The number of doubtful cases has been reduced, but there remains a considerable proportion of cases showing no excretion of Biligrafin in which the roentgen findings are inconclusive.

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SUMARIO

**La Colangiografía por el Método de la Biligrafina con o sin Colecistografía Oral Anterior. Esfuerzo Encaminado a Justipreciar la Fidedignidad del Método de la Biligrafina**

Preséntanse los resultados de la colangiografía con Biligrafina (Colografina) en una serie de 270 casos (237 en que había fracasado la colecistografía oral y 33 enfermos colecistectomizados). Lo mismo que en la colecistografía oral, se requirieron cifras de plasma inferiores a 20 para la visualización.

Los hallazgos operatorios en cuanto al estado del colédoco resultaron compatibles con los estudios roentgenológicos en 21 de 22 casos. Sugieren los hallazgos que la falta de visualización de la vesícula biliar al mismo tiempo que se visualizan los conductos biliares, después de la inyección de Biligrafina, indica graves alteraciones de la vesícula, del conducto cístico o de ambos, con obstrucción mecánica de la entrada del medio.

En varios casos de falta de visualización de la vesícula biliar con un medio opaco oral, esto ha ido seguido de clara visualización con la Biligrafina. Debe presuponerse por eso que el método oral ofrece más información acerca de la función de la vesícula que la colangiografía con Biligrafina, que no aporta dato alguno acerca de la facultad concentradora del órgano. Cuando se usa por sí solo, el método de la Biligrafina puede encubrir estados morbosos de la vesícula biliar.

A pesar de las probabilidades mucho mayores que ofrece la colangiografía con Biligrafina para justipreciar el estado del aparato biliar, todavía subsiste la dificultad para diferenciar entre una lesión primaria del parénquima hepático y una enfermedad del aparato biliar. Se ha reducido el número de casos dudosos, pero queda una proporción considerable de casos que no muestran excreción de Biligrafina en que los hallazgos roentgenológicos no son terminantes.

# Intravenous Cholangiography: Pitfalls in Interpretation[1]

HERBERT S. BERLIN, M.D.,[2] MAXWELL H. POPPEL, M.D., F.A.C.R.,[3] and JOSEPH STEIN, M.D., F.A.C.R.[4]

SHORTLY AFTER the introduction of Cholografin, numerous reports stressing the excellence of this new agent for the direct investigation of the biliary tree appeared. In the hands of Bell, Berk, Glenn, Orloff, their associates, and others (1–4), and at our own hospital, symptomatic postcholecystectomy states often have been resolved into basic abnormalities amenable to definitive therapy. Unusual conditions in the region of the intra- and extrahepatic biliary tree, including tumor, inflammation, and sinus tracts, have been visualized with Cholografin. Gallbladders unresponsive to oral cholecystographic media have been opacified, allowing positive preoperative diagnoses.

The purpose of this report is not to detract from the proved worth of intravenous cholangiography with Cholografin, but to illustrate several pitfalls in the interpretation of such roentgenographic studies and means for their avoidance.

## PITFALLS

*A. Masking Effect of Small Lucent Calculi:* Small lucent calculi may be missed, their presence masked by the dense opacification occasionally produced by Cholografin even in a diseased gallbladder.

*B. Images Produced by Overlap of Shadows:* The superimposition of shadows of organs in the right upper quadrant of the abdomen, *i.e.* the sharp edge of the liver, the renal silhouette, and loops of bowel which may contain some of the opaque material, often produce deceiving images on the radiograph. In particular, the overlapping shadows of liver and kidney may be confused with the gallbladder.

*C. Renal versus Biliary Clearance:* In the early phase of excretion, renal clearance may simulate biliary passage, and *vice versa*. This is especially true when the right renal pelvis is bifid and the superior major calyceal system is on the same anteroposterior plane as the biliary ducts.

*D. Stratification Phenomenon:* On occasion, Cholografin may gravitate to the dependent portion of a normal gallbladder, with preservation of the interface between the bile and iodinated media, producing a unique circular radiolucency suggesting a large lucent stone or free gas within the gallbladder.

## CASE REPORTS

The following cases illustrate these potential errors.

CASE I: A 57-year-old male was admitted to the Bronx Veterans Administration Hospital acutely ill, complaining of epigastric pain, nausea, and vomiting. He related a history of long-standing intolerance to fatty foods. There were no urinary complaints or findings. A plain film of the abdomen disclosed a suspicious calcification in the right upper quadrant (Fig. 3A). Oral cholecystography demonstrated a gallbladder having a phrygian cap and containing numerous small radiolucent stones (Fig. 1B). The calcification previously noted was again seen and considered possibly to be within the common bile duct.

Intravenous cholangiography showed a well opacified and grossly normal gallbladder (Figs. 1A and 2A) and a structure presumed to be the common duct, leading directly to the unidentified calcification, which was now felt with more certainty to represent an intraductal stone (Fig. 2).

At laparotomy, the diseased gallbladder containing numerous stones was removed. The common duct, however, was normal.

Postoperative films of the abdomen demonstrated a slow, gradual descent of the calcific density, which on an intravenous pyelogram was shown to be within the right ureter (Fig. 3, B and C).

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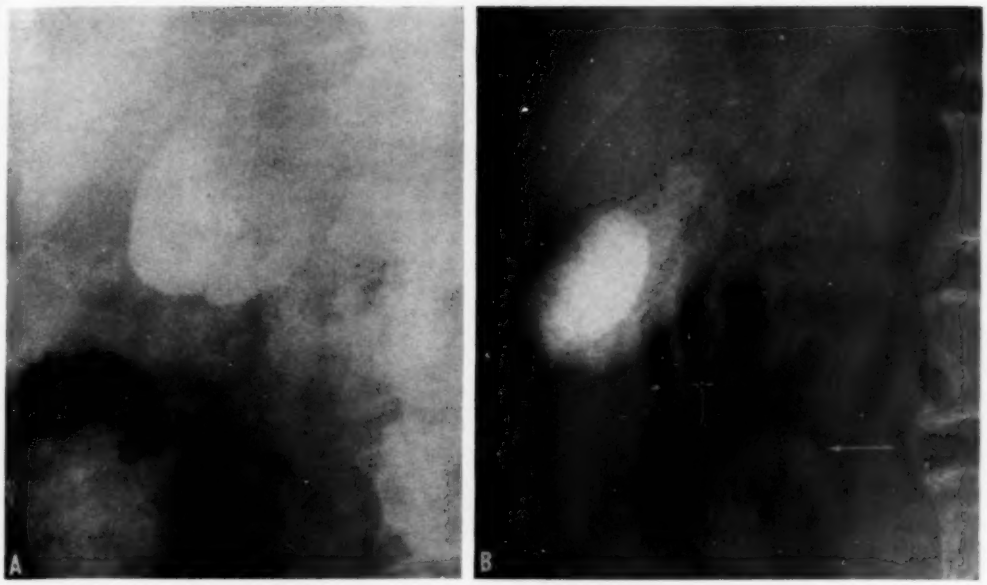


Fig. 1. Dense opacification of the gallbladder by Cholografin, (A), masking the multiple lucent areas demonstrated by oral cholecystography (B). Note the phrygian cap and the calcification in the right upper quadrant.

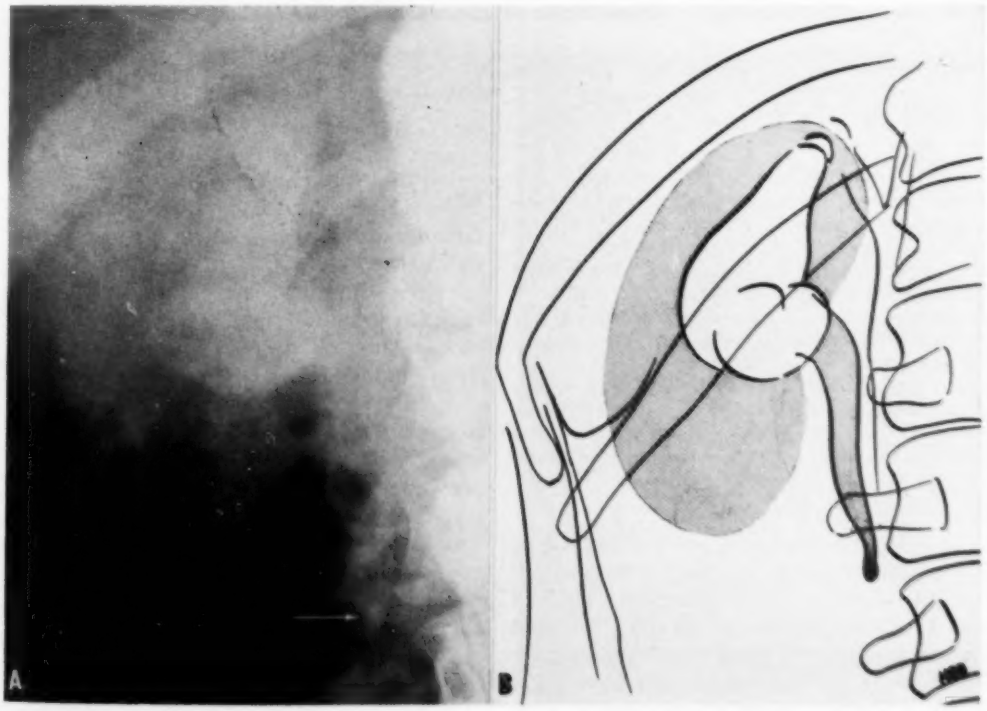


Fig. 2. A. Roentgenogram obtained one hour after injection of Cholografin, showing a normal appearing gallbladder and calcification thought to be in the common duct.

B. Tracing showing the actual location of the calculus within the ureter. The normal common duct is situated superiorly and medially. (Kidney and ureter are shaded.)

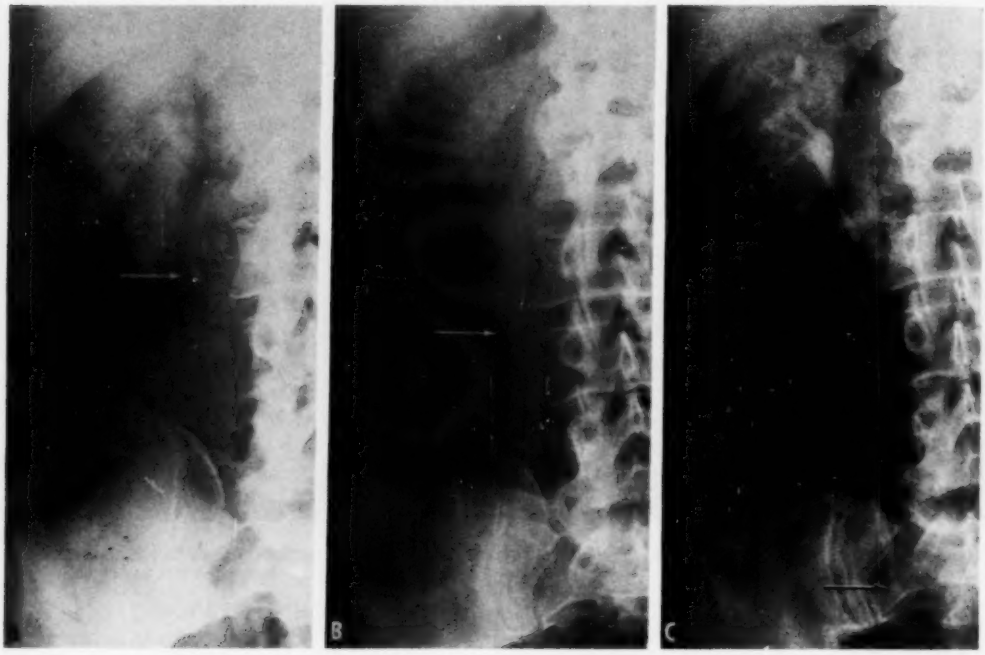

Fig. 3. A. Plain film obtained on admission, disclosing abnormal right upper quadrant calcification.
B. Twenty days later the calculus has descended slightly.
C. Intravenous pyelogram made thirty days after admission, showing further descent of the calculus now identified in the right ureter.

CASE II: A 29-year-old patient with active duodenal ulcerative disease was investigated for a persistent extrinsic appearing pressure defect in the post-bulbar region. Oral cholecystography resulted in poor opacification of the gallbladder. Cholografin was employed to clarify the problem, and an unusual large circular area of radiolucence was delineated in the gallbladder fundus, which in upright and decubitus positions showed a "fluid level" (Fig. 4).

The possibilities of free gas within the gallbladder, a large lucent stone, or both, were entertained. At surgery, a normal gallbladder and a grossly scarred duodenal cap and post-bulbar segment were found.

## DISCUSSION

In our first case, the unique ability of Cholografin to opacify occasionally even the chronically diseased gallbladder masked the numerous lucent calculi demonstrated in the preliminary oral cholecystographic examination. This was mentioned as a theoretical possibility by Graham in his discussion of the paper by Glenn *et al.* (3), and emphasizes the necessity for oral cholecystography as the initial step on routine pre-cholecystectomy investigations, to be followed by intravenous cholangiography when indicated. In retrospect, the structure felt to represent the common duct appears actually to have been the proximal right ureter incompletely blocked by the stone. The common duct itself could be seen less clearly, medially (Fig. 2B). A film of the abdomen with the patient in a right posterior oblique position would have separated these shadows and prevented an incorrect diagnosis.

The second case demonstrated a phenomenon noted by others. It is likely that the heavily iodinated bile gravitates below the lighter accumulation of bile and causes the stratification.

## SUMMARY

Several potential sources of error in intravenous cholangiography with Cholografin are discussed and illustrated in 2 case reports. On the basis of our experi-

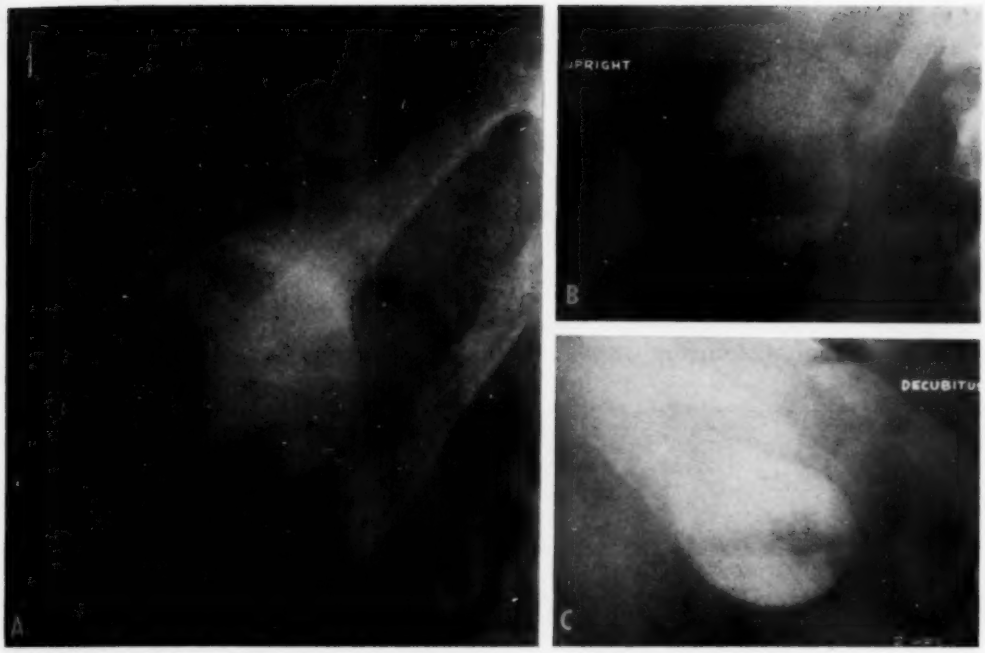


Fig. 4. A. Roentgenogram obtained eighty minutes after injection of Cholografin, with the patient prone. A peculiar circular area of radiolucency is apparent in the partially filled gallbladder.
B and C. Stratification phenomenon demonstrated at two hours in upright and right lateral decubitus positions.

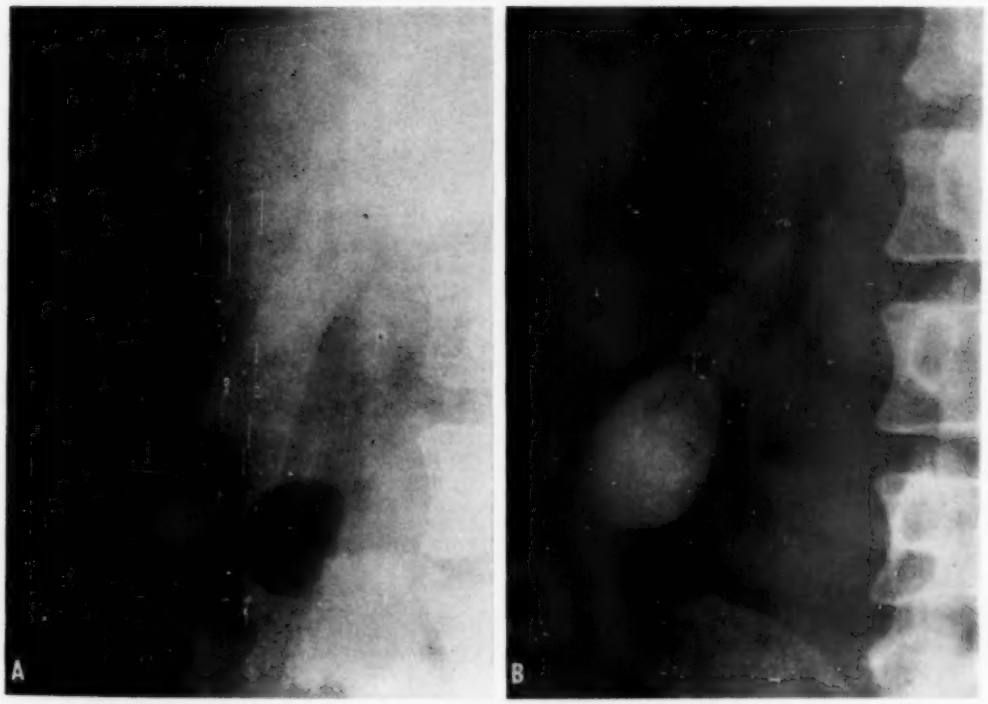


Fig. 5. Layering effect in a patient with chronic relapsing pancreatitis. The stratification noted in A is disturbed by the mixing following the stimulus of a fatty meal.

ences, the following recommendations are made:

1. Oral cholecystography should routinely precede Cholografin studies, in patients who have not undergone cholecystectomy, to provide a functional evaluation and serve as a baseline study of the gallbladder. The structural status of the gallbladder and its ductal tree may then be investigated more thoroughly with Cholografin.
2. Tomography should be employed to eliminate obscuring gas and organ shadows in the right upper quadrant of the abdomen.
3. Right posterior oblique views should be employed when ductal visualization is obtained, to separate the biliary tree from the underlying renal collecting system.
4. The effect of layering alone, *i.e.*, without the presence of stones floating at the interface, is normal and will be seen in a small percentage of patients examined with Cholografin. The interface may be broken by means of a fatty meal stimulus, or avoided by ingestion of a fatty meal approximately one hour prior to the intravenous cholangiography.

NOTE: The authors wish to express their thanks to Mrs. M. Nesson for her careful transcription of the manuscript.

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SUMARIO

**La Colangiografía Intravenosa. Escollos en su Interpretación**

Enuméranse aquí ciertos escollos inherentes en la interpretación de los colangiogramas intravenosos obtenidos con la Colografina: (*a*) el efecto enmascarador de los calculillos lucientes debido a la espesa opacidad producida a veces por la Colografina hasta en una vesícula biliar enferma; (*b*) la sobreposición de sombras de órganos en el hipocondrio derecho, en particular del hígado y del riñon; (*c*) simulación de despejo renal por el despejo biliar, y vice versa, en la fase incipiente de la excreción; (*d*) fenómeno de la estratificación, a saber, la gravitación de la Colografina a la porción baja de una vesícula biliar, con conservación de la intercara entre la bilis y los medios, sugiriendo un cálculo luciente grande o la presencia de gas libre.

Dedúcese que la colecistografía oral debe preceder sistemáticamente los estudios con Colografina en los enfermos que no han sido colecistectomizados, a fin de obtener una justipreciación funcional y de contar con un estudio básico de la vesícula biliar. Puede entonces investigarse más a fondo con Colografina el estado anatómico de la vesícula y de su red de conductos.

Preséntanse dos historias clínicas.

# Pseudohypoparathyroidism[1]

JOSEPH V. CUSMANO, M.D., DAVID H. BAKER, M.D., and NATHANIEL FINBY, M.D.

PSEUDOHYPOPARATHYROIDISM is a familial disease of metabolism in which the parathyroid glands are apparently normal in structure and function but organ response to the parathyroid hormone is abnormal. The condition was first described by Albright and his colleagues in 1942 (1), when the term "Seabright bantam syndrome" was applied to it by analogy with the condition observed in Seabright bantam roosters. The chief feature distinguishing it from other forms of chronic hypoparathyroid tetany is the lack of response to parathormone. The diagnosis can be suspected from radiographic study of the hands and skull.

Elrick, Albright *et al.* in 1950 (2) collected 14 cases and emphasized the following features of the disease:

1. Clinical and laboratory evidence of chronic parathyroid insufficiency; tetany without evidence of renal disease, steatorrhea, or generalized osteomalacia. Despite these findings, patients show little or no response to parathormone.
2. Shortening of metacarpal and metatarsal bones.
3. Clinical picture of shortness of stature, thickset appearance, round facies, mental retardation and short stubby fingers.
4. Soft-tissue calcification involving

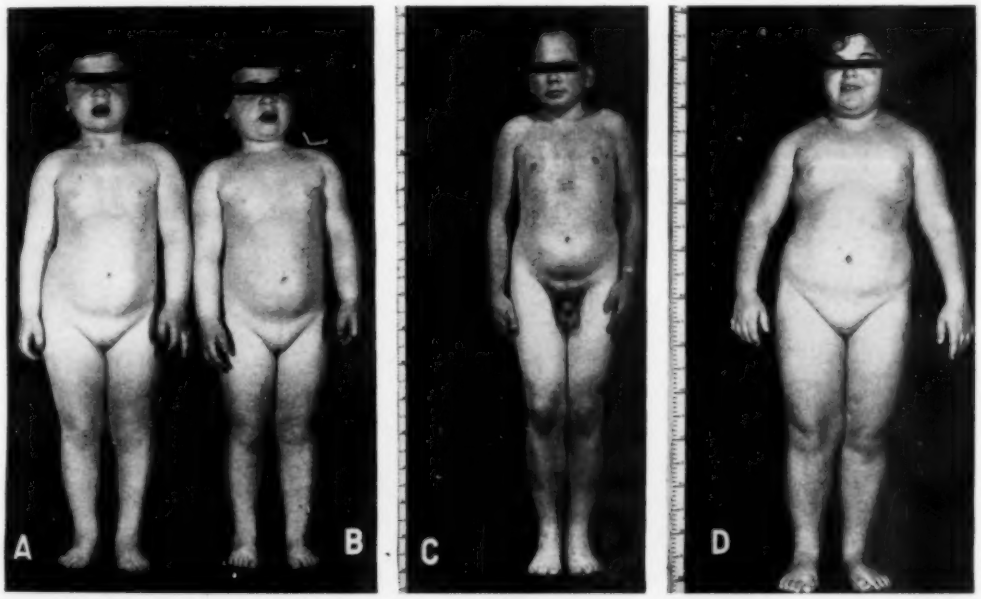


Fig. 1. Body configuration. A. Case I. Patient at six years of age. Note short, stocky build and round facies. Tracheostomy scar is visible. B. Case II. Twin sister of the first patient, with similar body build. C. Case III. Patient at age of nineteen years. Note short, thickset body configuration. D. Case V. Patient at age of eleven years. Note short, rotund body build with round facies and stubby fingers.

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Figs. 2–5. Case I

Fig. 2. Thickening of the calvarium, particularly in frontal and parietal areas. Inner and outer tables are of normal appearance, but the diploic space is spongy.

Fig. 3. Left, hand, showing short first, fourth and fifth metacarpals. Epiphyseal lines are not closed in the shortened metacarpals. The middle phalanx of the fifth finger is short.

Fig. 4. Short third, fourth, and fifth metatarsals, bilaterally. Soft-tissue ossification is clearly seen in the left foot. A metatarsus varus-hallux valgus deformity is present bilaterally.

Fig. 5. Large area of soft-tissue ossification dorsal to distal tibia and ankle joint. There is also soft-tissue calcification beneath the calcaneus.

the basal ganglia and subcutaneous tissues.

Our purpose in this presentation is to add 6 new cases to the 30 now appearing in the literature and to emphasize the diagnostic roentgen features.

Fig. 6. Case II. The skull is normal except for thickening of the calvarium, most marked in the frontal area.
Fig. 7. Case II. Shortening of first, fourth, and fifth metacarpals bilaterally and of left third metacarpal. The middle phalanx of each fifth finger is shortened, most markedly on the right.

## CASE REPORTS

Case I: A 12-year-old white twin girl gave a history of inspiratory stridor four weeks after birth. At five months she began to have frequent episodes of croup, which continued intermittently until the age of six. During a severe attack at four years of age a tracheostomy was required. At the age of five years twitching of the hands and face developed.

A "spur" was noted on the right heel when the patient was eighteen months old. There were also hard, raised macular areas in the skin of the abdomen. Biopsy showed normal bone tissue at both sites (osteitis cutis in the skin of the abdomen).

The diagnosis of pseudohypoparathyroidism was made by Dr. F. Albright in May 1948. Blood calcium at that time was 6.0 mg. per cent, blood phosphorus 2.6 mg. per cent, and alkaline phosphatase 10 King-Armstrong units. There was no urinary phosphorus diuresis after the intravenous administration of parathormone (Ellsworth-Howard test). The patient improved on treatment with Amphogel and dihydrotachysterol (A.T. 10).

On first admission, at six years of age, the patient was a short, stocky, co-operative child with a round face, short hands, and stubby fingers (Fig. 1A). Dorsiflexion of the left ankle was limited, and deep tendon reflexes were hyperactive. Chvostek and Trousseau reflexes were not elicited.

Laboratory studies showed: blood calcium, 9.1 mg. per cent; phosphorus, 4.1 mg. per cent; alkaline phosphatase, 4.9 units. Total protein was 6.9 mg. per cent, with a 2.5/1 ratio. Renal function studies were normal.

Radiographic studies showed a thickened calvarium with a spongy diploic space (Fig. 2). There was shortening of the first, fourth, and fifth metacarpals (Fig. 3) and the third, fourth, and fifth metatarsals (Fig. 4) bilaterally, and of the middle phalanx of the left fifth finger. Soft-tissue calcification was seen in the right hand, left wrist, and left lower extremity, extending from knee to foot. In the region of the left ankle the calcific deposits were abundant and of bony texture (Fig. 5). Similar bony collections were also present in the foot about the second and third metatarsals, extending into the toes (Fig. 4). No calcification of basal ganglia was seen.

The child was treated with varying regimens of vitamin D and showed good response.

Case II: The twin sister of our first patient was first seen in The New York Hospital in March 1949, with a history of stridor developing at an early age, associated with croup. Her mental development was slow, similar to that of her sister. Twitching of hands and face was noted at the age of five years.

The diagnosis of pseudohypoparathyroidism was made by Doctor F. Albright in 1948. Blood calcium at that time was 5.4 mg. per cent, phosphorus 8.5 mg. per cent, alkaline phosphatase 8.5 King-Armstrong units. As in Case I, there was no urinary phosphorus diuresis following intravenous parathormone administration. Treatment was with A.T. 10 and Amphogel until admission.

On first admission, at the age of six, the child displayed the same general appearance as her sister (Fig. 1B). She had bilateral internal strabismus, and hyperactive deep tendon reflexes. No Chvostek or Trousseau reflexes were elicited.

Laboratory studies showed: blood calcium 9.2 mg. per cent; phosphorus 5.0 mg. per cent; alkaline phosphatase 2.8 Bodansky units. Renal function studies were normal.

Radiographic examinations demonstrated a thickened calvarium with a widened spongy diploic space (Fig. 6). Soft-tissue calcification was noted in the left ankle and both feet. The hands showed shortening of the first, fourth and fifth metacarpals on the right and shortening of the first, third, fourth, and fifth

Fig. 8. Case III. Marked thickening of entire calvarium. Calcification in basal ganglia (arrows).

thesias and pain in the fingers. He had been under intermittent medical care since infancy for a "gland condition"; motor and mental development was retarded. At the age of fifteen years, the blood calcium had been found to be 7.2 mg. per cent, blood phosphorus 6.4 mg. per cent, and alkaline phosphatase 28.5 Bodansky units.

The patient was short and thickset, with a round face, short thick hands, and stubby fingers (Fig. 1C). Bilateral lens opacities, delayed dentition, positive Chvostek and negative Trousseau reflexes were observed.

Laboratory studies, after treatment with vitamin D, revealed a blood calcium of 11.4 mg. per cent, phosphorus of 4.8 mg. per cent, and alkaline phosphatase of 3.0 Bodansky units. Blood electrolytes and renal and thyroid function studies were normal. The Ellsworth-Howard test showed no response in urinary phosphorus excretion.

Radiographic studies of the skull (Fig. 8) demonstrated marked thickening of the entire calvarium, involving all tables, especially the dense outer table, and the spongy diploic space. The frontal sinus was greatly enlarged. There were areas of punctate and amorphous calcification in the region of the basal ganglia bilaterally. The roots of the molar teeth were incompletely developed.

There was pronounced shortening of the first, fourth, and fifth metacarpals bilaterally (Fig. 10), with thickening of the cortical margins, coarsening of the trabecular pattern, and widening of the medullary space in the shortened bones. The hands appeared wide and short, with enlargement of the terminal phalangeal tufts. The feet showed shortening of the third and fourth metatarsals on the right and the fourth on the left (Fig. 9).

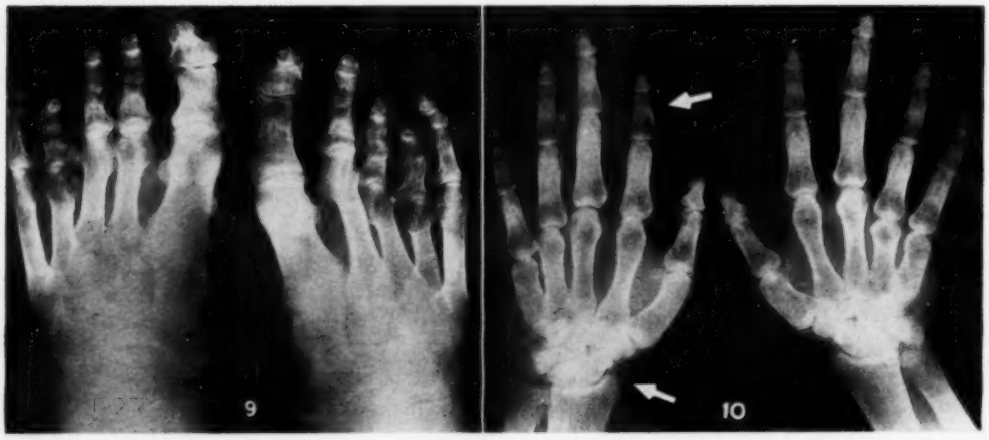


Fig. 9. Case III. Shortening of the third and fourth metatarsals on the right and the fourth on the left. Soft-tissue calcification is best seen medial to left first metatarsal.

Fig. 10. Case III. Marked shortening of first, fourth, and fifth metacarpals bilaterally. Soft-tissue calcification is shown by arrows.

metacarpals on the left (Fig. 7). There was slight shortening of the middle phalanx of each fifth finger. A bilateral metatarsus varus-hallux valgus deformity of both feet, with shortening of the four lateral metatarsal bones, was noted bilaterally. An irregular bony defect was seen in the anterior superior margin of the body of the second lumbar vertebra; radiographically the appearance suggested a localized epiphysitis. No evidence of calcification was seen in the region of the basal ganglia.

The child was treated with vitamin $D_2$ with varying dosage regimens and her blood chemistry has remained normal. Clinically she is doing well.

CASE III: A white male of 19 years was seen because of stiffness and pain in the legs, and pares-

Soft-tissue calcification was noted in the feet, ankles, legs, upper thighs, forearms, wrists, and fingers, and there were patchy areas of calcification distributed asymmetrically in the extremities. Examination of the spine showed mild vertebra plana and small areas of calcification in the anterior longitudinal ligament.

Under varying regimens of calcium therapy, the patient has shown no recent manifestations of tetany.

Fig. 11. Case IV. Frontal view of skull showing spongy thickening of the calvarium.

CASE IV: A white woman was seen in September 1947, with a history of hand spasm beginning at the age of ten years and continuing for three years. She was then well until the age of nineteen, when she again experienced hand and foot spasms. These symptoms gradually increased and were associated with twitching of the eyelids and facial muscles.

Laboratory studies in 1949, when the patient was twenty-eight, showed a blood calcium of 7.2 mg. per cent and a blood phosphorus of 5.4 mg. per cent. Renal function studies were normal.

Radiographic examinations showed shortening of the first, fourth, and fifth metacarpals and slight shortening of the fourth and fifth metatarsals bilaterally. The calvarium (Fig. 11) was thickened, most markedly in the frontal and parietal areas. A small lucent defect with lobulated sclerotic margins

Fig. 12. Case V. Marked shortening of fifth metacarpal and slight shortening of fourth metacarpal, bilaterally.

was noted in the left frontal bone; its radiographic appearance suggested cholesteatoma. Poorly defined punctate calcifications were observed in the region of the basal ganglia. No other soft-tissue calcifications were seen. Treatment with vitamin D was followed by gradual disappearance of symptoms. The patient has been well without medication since June 1953.

CASE V: An 11-year-old white girl was seen in September 1951, because of shortness of stature and retarded mental development. She had been treated with "gland injections" for two years and oral thyroid medication for three years, without improvement.

The patient was short and fat, co-operative but retarded, with a round face, short fingers, and stubby hands (Fig. 1D). Chvostek and Trousseau reflexes were not elicited. All the deep tendon reflexes were hyperactive.

Laboratory studies showed a blood calcium of 7.3 mg. per cent, blood phosphorus of 5.1 mg. per cent, and alkaline phosphatase of 10 Bodansky units. Total protein was 7.7 mg. per cent, with a 3/1 ratio. Renal and thyroid function studies were normal.

Radiographic examination revealed slight shortening of the fourth and pronounced shortening of the fifth metacarpal bilaterally (Fig. 12). No ectopic calcification was seen. The teeth were of normal appearance. Films of the skull and feet disclosed no abnormality.

The patient was discharged without specific medication and is doing well.

CASE VI (courtesy of Dr. H. P. Goldberg): A white girl of 5 1/2 years was first seen in May 1955, with a history of tonic seizures. Leg and forearm pains associated with fist clenching had been present for three months. Physical and mental development had been slow.

The child was short and stocky, with a round face and stubby hands. Positive Chvostek and Trousseau signs were elicited.

Fig. 13. Case VI. Short first, fourth and fifth metacarpals bilaterally. The middle phalanges of both fifth fingers are short.

Laboratory studies showed a blood calcium of 6 mg. per cent, blood phosphorus of 13.3 mg. per cent, and alkaline phosphatase of 12.5 Bodansky units. Total protein was 6.5 mg. per cent, with a normal ratio. A urine Sulkowitch test was negative and the Ellsworth-Howard test showed no significant increase in phosphorus excretion. Renal and thyroid function studies were normal.

Radiographic examination showed shortening of the first, fourth, and fifth metacarpals bilaterally (Fig. 13) and slight shortening of the third and fourth metatarsals bilaterally. The middle phalanges of both fifth fingers were short. The calvarium was normal and there was no evidence of abnormal intracranial or other soft-tissue calcification.

The patient was treated with calciferol and has been asymptomatic, with a normal blood calcium level.

## DISCUSSION

Hypoparathyroidism is most commonly seen following thyroidectomy, after inadvertent or unavoidable removal of the parathyroid glands. Spontaneous or idiopathic hypoparathyroidism is a rare disease. Albright recognized the occurrence of two forms of this latter condition when he found that certain cases failed to respond to large doses of parathormone (1). It is these cases that are designated pseudohypoparathyroidism.

The Ellsworth-Howard test, which consists in the intravenous injection of parathormone and subsequent urinary phosphorus determination, thus becomes an index of end-organ response. In normal individuals and in cases of hypoparathyroidism other than pseudohypoparathyroidism, urinary phosphorus excretion is increased following parathormone injection. In pseudohypoparathyroidism, there is no appreciable rise in phosphorus excretion.

In an excellent review of the literature and critical analysis of the previously reported cases, Macgregor and Whitehead (3), in 1954, pointed out the fallibility of the Ellsworth-Howard test in the diagnosis of pseudohypoparathyroidism. They emphasized the specificity of the osseous and soft-tissue changes and concluded that "chronic tetany, together with brachydactyly and the characteristic metacarpal or metatarsal changes, or with ectopic calcification or bone formation," is "undisputed proof" of pseudohypoparathyroidism.

They added 3 new cases to the 24 previously reported acceptable cases. Three additional cases (4–6) have been found to fit our criteria, making a total of 30 cases in the literature.

The age has varied between seven and forty-nine years (3) in the majority of cases, although the condition has been reported at sixteen months (6). Awareness of the syndrome should allow earlier recognition. Our patients ranged in age from five and a half to twenty-nine years. Although 5 of the 6 were females, Macgregor and Whitehead found no significant sex variation. It is interesting that 4 of our 6 patients were Jewish.

Symptomatology is related predominantly to episodes of hypocalcemia. Tetany, with manifestations of stridor, muscular hyperexcitability, tonic convulsions, tingling, and cramps of the extremities, is seen at some time in every patient with this disease. Other findings of significance are mental retardation, delayed and defective dentition, cataract formation, and the characteristic round face and short, stocky appearance. Older persons, such as our third patient, may show immobile facies and posture suggestive of Parkinson's disease.

In 1952, Albright *et al.* (13) presented a case with the typical roentgen features of

pseudohypoparathyroidism without hypocalcemia or tetany. Since there was no chemical sign or clinical symptom of hypoparathyroidism, Albright suggested the diagnosis of "pseudo-pseudohypoparathyroidism." The mother of our sixth patient shows similar findings. She is 4 feet 8 inches tall, is of average intelligence, and gives no history of symptoms which could be interpreted as being related to hypocalcemia. She showed a normal calvarium without evidence of thickening of the tables or calcification in the region of the basal ganglia. Her first, fourth, and fifth metacarpals were found to be shortened bilaterally, and her fourth metatarsal was markedly shortened, also bilaterally. Soft-tissue calcification was not present. Her sister, who is also very short, but who was not seen by us, allegedly had arm and leg pain associated with "spasms of the fingers" during her teens.

The occurrence of these radiographic findings in the mother of a patient with a familial disease which is thought to represent several inborn "errors of metabolism" raises the possibility of *formes frustes* of pseudohypoparathyroidism. A study of the family trees of patients with pseudohypoparathyroidism may be fruitful in this respect. The term "pseudo-pseudohypoparathyroidism" is not practical and, with further study along these lines, one or more of the "metabolic errors" will be identified as a part of the syndrome of pseudohypoparathyroidism.

## ROENTGEN FEATURES

*Hands and Feet:* Commonly, the first, fourth, and fifth metacarpals and the first and fifth metatarsals are short in patients with pseudohypoparathyroidism (1, 2, 3). Our patients showed predominant shortening of the fourth and fifth metacarpals and the fourth metatarsal. The involved bones are frequently wider than normal. The hands reflect the changes by lack of prominence of the involved knuckles when the fist is clenched (13).

The hand findings in various osteochondrodystrophies may resemble pseudohypoparathyroidism, although the characteristic patterns of shortening do not occur in the former. Familial brachydactyly and the shortening of the metacarpals in myositis ossificans progressiva may produce radiographic patterns identical with those of pseudohypoparathyroidism.

We have observed short fourth and fifth metacarpals also in normal patients. The radiographic appearance of these hands is often similar to that in pseudohypoparathyroidism. Thus, the metacarpal changes are not by themselves diagnostic of the disease.

Elrick and his associates state that the metacarpal shortening is due to early closure of the involved epiphyses (2). In all our cases, however, the primary ossification centers (the shafts) were shortened during growth and the secondary epiphyseal plates did not close earlier than those of the normal metacarpals or phalanges. An anteversion of the distal ossification center may simulate early closure.

*Intracranial Calcification:* Calcification in the basal ganglia in pseudohypoparathyroidism is usually seen in older patients. It was reported in 10 of the 30 cases in the literature and was observed in 2 of our patients. The radiographic appearance, which may be subtle, was well described by Camp (7) in patients with hypoparathyroidism. Similar change can occur in otherwise normal individuals.

*Soft-Tissue Calcification and Ossification:* Extraskeletal calcification and ossification in the extremities have been reported in about two-thirds of cases of pseudohypoparathyroidism. These usually occur in the vicinity of joints, especially in the hands and feet. Most often they appear as small fragments but may be seen as cords and plaques. Rarely, as in our Cases I and III, they produce painful subcutaneous nodules and limitation of motion. In other forms of hypoparathyroidism the soft-tissue calcifications occur almost exclusively in the brain, and deposits in soft-tissues of the skeleton are therefore a valuable differential diagnostic aid. This is an important point, since

soft-tissue calcification may be seen in the absence of metacarpal changes.

*Skull:* Thickening of the calvarium was a prominent feature of our cases and is of special interest, since a review of the literature revealed no more than a brief mention of its occurrence (8, 9). It was present in some degree in 4 of our 6 patients, and seems worthy of greater emphasis. In severe form, as in Case III, the diploic space is markedly widened and spongy and in some areas has a striated appearance. With lesser thickening, the widened diploic space appears granular. The thickened skull is less dense than normal.

Progression of the skull changes was noted in 2 of our cases (I and II) despite treatment of the pseudohypoparathyroidism. This is in agreement with the concept that pseudohypoparathyroidism is a syndrome consisting of several unrelated genetic defects which occur simultaneously.

In patients with hemolytic anemia and healed rickets there may be skull changes resembling those described above. These are usually easily differentiated and, for this reason, we feel that thickening of the calvarium, when it is present, may be the most significant diagnostic change of pseudohypoparathyroidism.

*Miscellaneous Radiographic Findings:* Bowing of the extremities, osteoporosis, and exostosis are occasionally noted in conjunction with the other findings. Accelerated skeletal maturation is sometimes seen; it was present in 4 of our younger patients. Failure of calcification of the teeth will be seen in untreated patients who manifest the disease during dental development. It is well described in Albright's text (14) and can occur in all forms of hypoparathyroidism.

## SUMMARY

It is evident that pseudohypoparathyroidism is a familial disease with three components: *first*, the metabolic defect, manifest as a failure to respond to parathormone; *second*, bone dysplasia; *third*, extraskeletal calcification and ossification.

The roentgen findings of short metacarpals, thickened calvarium and extraskeletal calcification, singly or in combination, in patients with symptoms of parathyroid insufficiency, should suggest the diagnosis of pseudohypoparathyroidism.

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SUMARIO

**Seudohipoparatiroidismo**

Preséntanse 6 casos de seudohipoparatiroidismo, haciendo hincapié en las características roentgenológicas. Dos de los 6 casos fueron en gemelas.

El seudohipoparatiroidismo es una enfermedad familiar con tres componentes: (1) un defecto metabólico expresado en la falta de respuesta a la "parathormona" con una hiperexcreción urinaria de fósforo; (2) displasia ósea; (3) calcificación y osificación extraesqueléticas.

Los síntomas se relacionan con episodios de hipocalcemia y comprenden algún grado de tetania, con manifestaciones de estridor, hiperexcitabilidad muscular, convulsiones tónicas, comezón y calambres de los miembros; retardo mental; figura rechoncha, con cara redonda, manos chicas y dedos cortos y gruesos. Los hallazgos roentgenológicos comprenden metacarpianos cortos unidos a veces a acortamiento de los metatarsianos; calcificación de los ganglios basales, observada más comúnmente en los enfermos de mayor edad; espesamiento del calvario; calcificación y osificación del tejido blando, por lo general en la vecindad de las articulaciones, y sobre todo en las manos y los pies.

# Correlation of Cephalopelvimetry to Obstetrical Outcome with Special Reference to Radiologic Disproportion[1]

GERHART S. SCHWARZ, M.D.,[2] ROB H. KIRKPATRICK, M.D.,[2] and HAROLD M. M. TOVELL, M.D.[3]

IT HAS BEEN CLAIMED that there is inadequate statistical correlation of *pure* pelvimetry with obstetrical outcome (7). Moreover, the incidence of cesarean section in a group of patients with more favorable pelvic measurements has been found to be higher than in a group in which these measurements were less favorable (6). This is in striking contrast to the results obtained with the *cephalopelvimetric* methods of Chassar Moir (8), Caldwell, Moloy, and Steer (9), and Ball (1, 2), which indicate a definite correlation between the measured cephalopelvic difference and obstetrical outcome. All three of these methods are deficient in that their accuracy is lowest where it is most needed —namely at the mid-pelvis—when disproportion exists. Moreover, the borderline group, in which no roentgen prediction is possible on the basis of these methods, is too large. Indeed, it exceeds the group in which a diagnosis of disproportion can be made with assurance.

A preliminary study of the Ball method (12) was sufficiently promising to warrant further investigation because, of the three methods, it showed the smallest borderline group. The object of the study to be reported here was to correlate the findings by this method with the obstetrical results by charting both on graphs, to analyze the deficiencies of the method, and to suggest ways and means of correcting them.

## METHOD OF INVESTIGATION

Three hundred and fifty consecutive cephalopelvimetric examinations performed on ward patients of the Sloane Hospital for Women were studied. All patients were radiographed in the upright position at or near term, as described by Ball and Golden (2). For correction and computation of measurements a special slide rule (11) was substituted for the nomogram (5) employed by these authors. The films, including an additional stereoscopic inlet view, were sent to the Department of Obstetrics prior to measurement by the radiologist. All measurements were made by one of the authors (G. S. S.) *after* delivery, when the films were returned to the X-ray Department. Thus the radiologist's interpretation in no way influenced the management of delivery, a feature which makes this study unique. The obstetricians, however, had the opportunity of measuring the films by any method of their choosing (usually not the Ball method) and were at liberty to extract any information from the films *before* delivery and without the help of the radiologist.

Details for all patients with borderline and definitely unfavorable measurements and for all undergoing cesarean section or mid-forceps delivery were entered on graph sheets. To these were added a liberal cross section of patients who had been referred for cephalopelvimetry and found to have normal measurements and normal deliveries. A large number of normal cases were left uncharted in order to avoid crowding the graph sheets. These were included in the preliminary report (12) and do not affect the statistical significance of what we call radiologic borderline disproportion and high disproportion. They were used here only in the numerical evaluation of normal patients for the final tabulation of results.

Separate graphs were made for the inlet and the mid-pelvic measurements. On

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the x-co-ordinate the volume of the fetal head was recorded, whereas the y-co-ordinate denoted the volume capacity of the pelvis at the level for which the graph was chosen. Each case was entered on the graph as a symbol according to the obstetrical outcome. The meaning of the symbols is summarized in Table I. While *normal delivery* and *abnormal delivery for reasons other than disproportion* need no further explanation, the interpretation of *abnormal delivery due to disproportion* requires elaboration. The symbols are derived from a review of the obstetrical records of the patients in this category.

TABLE I: KEY TO SYMBOLS USED ON GRAPHS

| | |
|---|---|
| ○ | Normal vaginal delivery (including outlet forceps) |
| | Mid-forceps delivery: |
| ⊗ | For disproportion |
| ⊘ | For reasons other than disproportion |
| | Cesarean section: |
| ◜ | For reasons other than disproportion |
| ◉ | If repeat section |
| ● | Definite disproportion* |
| ◉ | If repeat section* |
| ■ | Probable disproportion* |
| ■ | If repeat section* |
| ▲ | Possible disproportion* |
| ▼ | Assumed disproportion* |

* Indication charted in hospital record as "disproportion," reviewed, accepted, and classified by authors. For details see section on review of hospital records.

## REVIEW OF OBSTETRICAL HOSPITAL RECORDS

All records of patients who had been studied radiographically and had undergone cesarean section or mid-forceps extraction, in which the obstetrician stated that disproportion had been found, were reviewed and the evidence for disproportion was critically assessed. *Definite disproportion* was accepted to exist in all cases in which no progress was apparent after eight hours or more of adequate labor; *probable disproportion* in those patients in whom the same situation obtained except that it was necessary to shorten the waiting period because of fetal distress; and *possible disproportion* in instances where fetal distress with arrest made cesarean section necessary and the quality of labor was inadequate. As a rule, in this last group labor was prolonged. Finally, the category of *assumed disproportion* comprised all patients without a trial of labor in whom disproportion was assumed by the obstetrician on the basis of his own interpretation of the radiographs or a history of previous complications.

No case was placed within the disproportion category which was not so classified on the hospital record. In one instance, the diagnosis of cephalopelvic disproportion was rejected, and the record was transferred to the group comprising cesarean section for reasons other than disproportion. As shown on the graphs, only three repeat sections occurred in the series, repeat sections being performed in most instances without benefit of radiography. Somewhat surprising is the fact that the majority of *all* sections were performed without roentgen studies. The sections in the series are only a fraction of the total number performed during this period (54 of 196). This testifies to the sparing use of roentgen cephalopelvimetry on our ward patients. Roentgenometry was requested only when a reasonable clinical doubt as to the presence or absence of disproportion existed.

## FINDINGS

The findings are best illustrated by the accompanying graphs. On Graphs 1 and 2 are recorded all operative deliveries, regardless of reason. No definite pattern can be recognized here. By elimination of all sections and all mid-forceps extractions for reasons other than disproportion, Graphs 3 and 4 were obtained. They demonstrate an unmistakable correlation between measurements and obstetrical outcome. The oblique lines delineating the borderline groups were chosen so as to produce the maximum possible correlation without sacrificing a safety margin. At the inlet, the borderline group extends from the line of equality (head volume equaling pelvic capacity, according to the Ball method) to a line representing an excess of

TABLE II. INCIDENCE OF CESAREAN SECTION OR MID-FORCEPS DELIVERY FOR DISPROPORTION* IN 350 ROENTGEN CEPHALOPELVIMETRY STUDIES

(Final computation of the highest accuracy of roentgen diagnoses obtainable with the Ball method prior to instituting the technical improvements outlined on pages 858–60. Percentage figures are rounded to the nearest whole)

| Incidence | Roentgen classification | | |
|---|---|---|---|
| | No radiologic disproportion | Radiologic borderline disproportion | High radiologic disproportion |
| At Inlet | 2% | 44% | 90% |
| At Midpelvis | 0% | 24% | 73% |

* Twelve cesarean sections and 9 mid-forceps deliveries for reasons other than disproportion were eliminated from a total of 54 cesarean sections and 11 mid-forceps deliveries.

head volume by 70 c.c. This borderline group is gratifyingly small (16 cases, as compared with 19 cases in the high disproportion group) and the accuracy of roentgen predictions is high. At the mid-pelvis (Graph 4) the situation is less favorable. Here the borderline group extends from a head excess of 90 c.c. to 220 c.c (total span, 130 c.c.). The number of borderline cases is, therefore, more than three times as great as the number of cases of high disproportion (35 versus 11). The accuracy of roentgen diagnoses in the high disproportion group is only 73 per cent. These findings are summarized in Table II. Any case charted on a line on the graph is counted in the group immediately above that line.

The final figures are based on 305 cases, 45 having been eliminated from the total because of lack of follow-up or incomplete measurements. In the majority of the latter cases, the interspinous diameter measurement was unavailable because of poor delineation of the ischial spines on the radiograph. In some, the fetal head was only partially visible as a result of breech presentation. Since these deficiencies were thought to be irrelevant to the case, repeat filming was dispensed with. In short, they were cases in which general inspection of radiographs or incomplete measurements appeared to provide enough information to make any additional roentgen exposure of the pregnant uterus unwarranted.

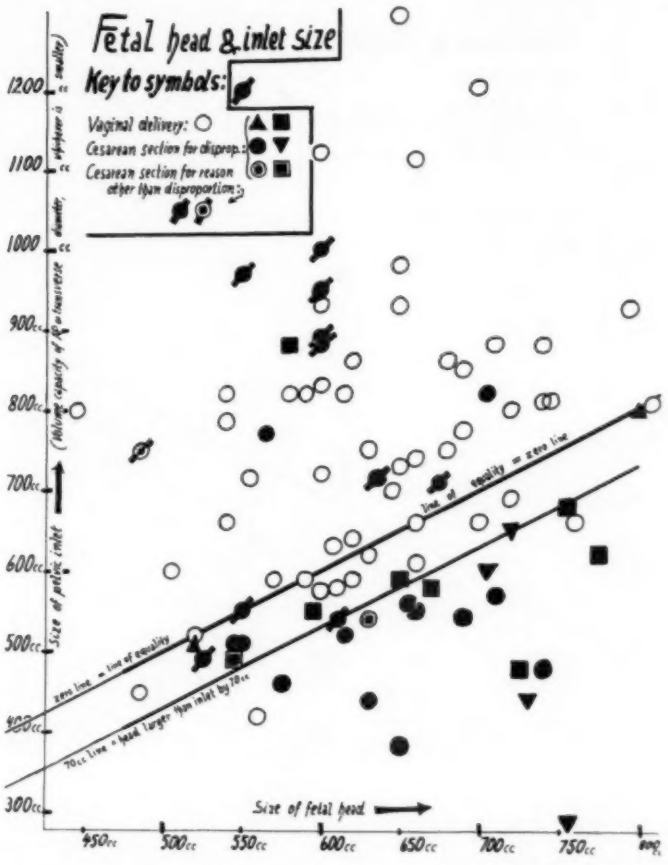
### OVERALL ACCURACY OF THE METHOD

Those authors assessing the value of the Chassar Moir method have expressed results in the form of an overall accuracy of "roentgen forecast" (10). In order to compare the Ball method with other methods, similar all-inclusive figures may be derived from our results.

If each roentgen diagnosis of borderline disproportion is considered correct (by definition, a borderline diagnosis can never be proved wrong by events), only 9 diagnostic failures occurred in 350 studies, representing an accuracy of 97.43 per cent. When the 45 technically incomplete studies are eliminated from the total, 296 correct diagnoses remain, or 97.05 per cent. If the 51 borderline diagnoses are also subtracted, as technical failures, from the total, though they remain as *correct diagnoses*, the percentage of accuracy becomes 96.45, 245 correct diagnoses in 254 studies. While these figures are identical with those reported to be obtained with the method of Chassar Moir, they are, however, misleading.

Table II shows the accuracy of the roentgen diagnoses to be high (98 to 100 per cent) in the absence of disproportion (a negative accuracy), and low (73 to 90 per cent) when disproportion is present (a positive accuracy). Since the great majority of studies in all series are proved to be normal, the overall figures are statistically weighted toward a too favorable result. Moreover, no single figure will express the greatest deficiency of all three methods, namely, the large number of borderline diagnoses. Statisticians remove such a borderline group by considering one-half its diagnoses as correct and one-half as incorrect. This would result in $51/2 + 9$, or 35 incorrect diagnoses, leaving 270 correct diagnoses in 305 studies, which is 88.52 per cent, or 315 correct diagnoses in the total of 350 studies, equaling 90 per cent.

The effect of the preponderance of nor-




Graph 1. Correlation between inlet size, fetal head size, and obstetrical outcome. For detailed key to symbols see Table I. All cesarean sections are charted here, regardless of whether or not cephalopelvic disproportion existed.

mal studies over abnormal studies upon the result can be eliminated by expressing the overall accuracy as the median between the negative and positive accuracy of the method. Thus, from Table II, the following percentages are obtained:

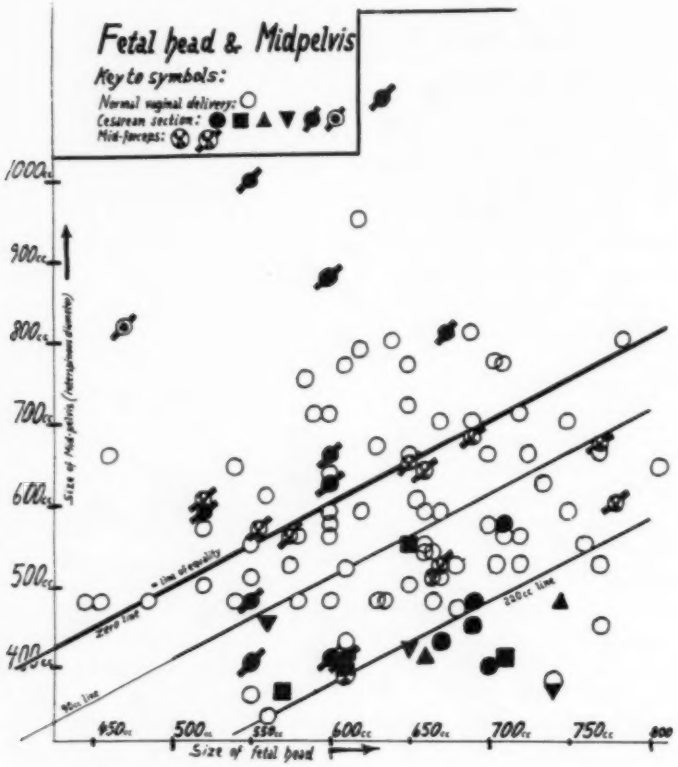
For the inlet: negative accuracy, 98 per cent; positive accuracy, 90 per cent; median, 94 per cent.

For the mid-pelvis: negative accuracy, 100 per cent; positive accuracy, 73 per cent; median, 86.5 per cent.

Though these figures are statistically correct, it is essential to realize that no all-inclusive figure will adequately represent the issue. They are given here only for purposes of comparison.

## ANALYSIS OF DISCREPANCIES

Of particular interest were 9 cases in which the outcome was clearly contrary to the measurements. In 5 instances, measurements indicated high disproportion, yet normal delivery took place and none of these children were abnormal at birth. In 1 case, a six-month follow-up was available and no evidence of birth injury was found. The reasons for these discrepancies vary. In 2 cases of roentgenologic mid-pelvic disproportion, the explanation lies in the difference between actual and available diameter of the fetal head. The interspinous diameter of the pelvis is not completely representative of the largest



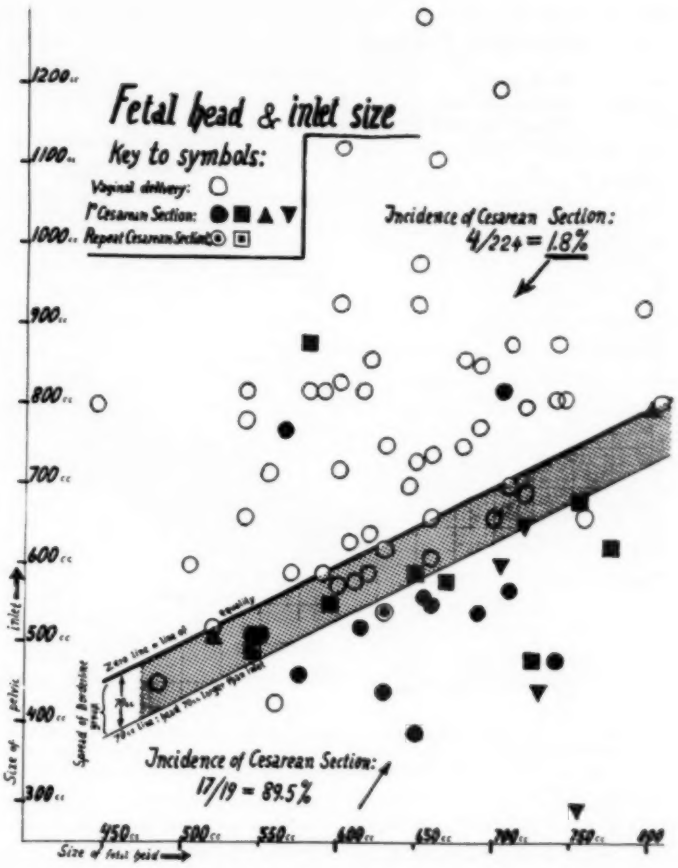

Graph 2. Correlation between size of midpelvis, fetal head size, and obstetrical outcome. For detailed key to symbols see Table I. All surgical deliveries are charted here regardless of whether or not cephalopelvic disproportion existed.

fetal head that can pass, because this diameter forms a chord to the head circle that can descend anterior or posterior to it. This deficiency is in part taken care of by allowing the large group of borderline cases shown on Graph 4. In the 2 cases of roentgenometric high disproportion at the inlet with normal delivery, the fetal head probably moved between the two exposures and thus gave rise to an incorrect geometrical correction. Simultaneous biplane radiography can eliminate this error. Biologic variation is, of course, a factor which must be considered in any of these discrepancies.

As to the cases in which inlet disproportion was encountered on delivery despite normal measurements, the events were no surprise. In 2 cases the inlet was of android shape and it was obvious that its anteroposterior and transverse diameters were not representative of the volume capacity. This could be seen clearly on the film and there was no diagnostic problem. In the third case, there was a persistent brow presentation in a flat inlet, and again measurements were overruled by qualitative considerations.

### TECHNICAL IMPROVEMENTS

In order to obtain a more reliable measurement of the interspinous diameter we have added an orthometric view (12) to the Ball method, which has an accuracy of better than 0.5 mm. A statistical survey of its merits (15) indicates at least a



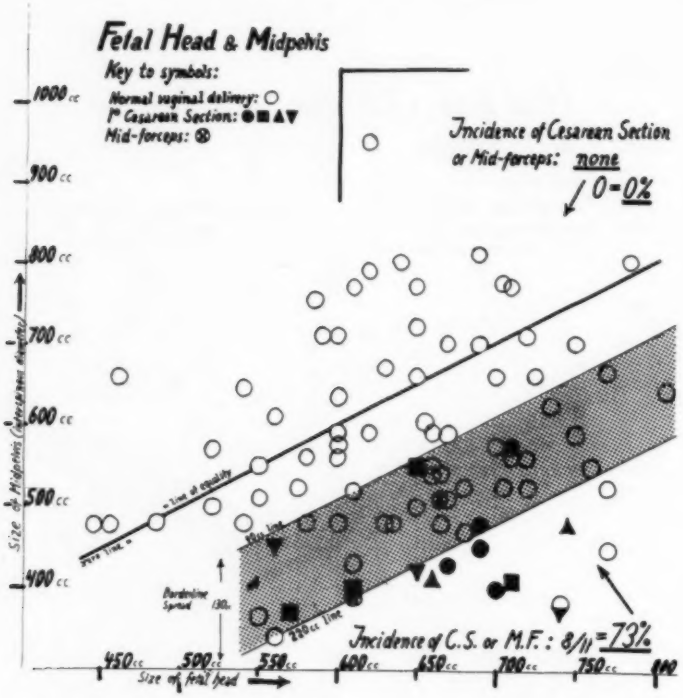

Graph 3. Correlation between inlet size, fetal head size, and obstetrical outcome. Same as Graph 1 except that all cesarean sections for reasons *other* than disproportion have been eliminated. For detailed key to symbols see Table I.

10 per cent improvement in accuracy of predictions at the mid-pelvis. In an occasional problem case, such as an android pelvis, we have resorted to fitting a circle into the inlet or the mid-pelvis, as in the method of Steer (9), considering this representative of the largest sphere that can pass. Its volume is then treated as the volume capacity of the pelvis, according to the Ball method.

For the inlet, this can be done on an appropriate inlet radiograph with a flexible loop (14) or a set of cardboard disks. For the mid-pelvis, an actual-size scale drawing is required; this is made from the measurements obtained through the Ball method, namely, the interspinous diameter, the low sagittal diameter, and its posterior segment. The procedure is a cumbersome one, but if the demand justifies it, tables will be set up to eliminate the need for a scale drawing.

Simultaneous biplane radiography might further improve the statistical accuracy of the Ball method, but we do not possess any equipment at present which would permit this.

Another remedy lies in a modification of the statistical method of classification. One can divide the borderline group at the mid-pelvis into a favorable segment extending from 90 to 190 c.c. (a span of




Graph 4. Correlation between size of midpelvis, fetal head size, and obstetrical outcome. Same as Graph 2 except that surgical deliveries for reasons *other* than disproportion have been eliminated. For detailed key to symbols see Table I.

100 c.c.) and an unfavorable segment extending from 190 to 220 c.c. In the former, the incidence of section or mid-forceps for disproportion is about 15 per cent, while in the latter it is 50 per cent. Whether or not such a subdivision of the borderline group is clinically useful is difficult to judge. Workers using the Chassar Moir method have always employed three or four different "degrees" of borderline disproportion (4, 16). Steer has divided his borderline group into two sections. For the purpose of an objective fundamental statistical analysis of the decisiveness of the roentgen diagnosis, only a single borderline group can be recognized, since we are dealing with the correlation of a "yes or no" proposition. Academically, there are no intermediate degrees of disproportion.

Purists, on the other hand, might object to the existence of any borderline group. It can be eliminated by combining it with the high-disproportion group into a single group which we might designate as "radiologically stigmatized." Then only a single line of division remains to separate the normal from the "stigmatized." The incidence of section in the stigmatized group is: at the inlet, approximately 70 per cent; at the mid-pelvis, 35 per cent.

This is a statistical artefact. The fundamental laws of biology produce an overlap between normal and abnormal values. A borderline group is therefore inevitable in biometry, but the better the method, the smaller the group.

## CONCLUSIONS

The following conclusions can be drawn from the findings:

1. There is a reasonable correlation between roentgen measurements and obstetri-

cal outcome when the Ball method of cephalopelvimetry is used.

2. Best results are obtained when the following roentgenometric classification is adopted:

*For the Inlet:*

A. "No Disproportion": All cases in which the volume of the fetal head is smaller than or equal to the volume capacity of the inlet.

B. "Borderline Disproportion": All cases in which the volume of the fetal head exceeds the volume capacity of the inlet but by not more than 70 c.c.

C. "High Disproportion": All cases in which the volume of the fetal head exceeds the volume capacity of the inlet by more than 70 c.c.

*For the Mid-Pelvis*

A. "No Disproportion": (1) All cases in which the volume of the fetal head is smaller than or equal to the volume capacity of the bispinous diameter. (2) All cases in which the volume of the fetal head is larger than the volume capacity of the bispinous diameter but does not exceed it by more than 90 c.c.

B. "Borderline Disproportion": All cases in which the volume of the fetal head exceeds the volume capacity of the bispinous diameter by more than 90 but not more than 220 c.c.

C. "High Disproportion": All cases in which the volume of the fetal head exceeds the volume capacity of the bispinous diameter by more than 220 c.c.

3. The following deficiencies have become apparent: (A) The method is less accurate at the mid-pelvis than at the inlet. (B) The method is less accurate in the presence of disproportion than in its absence, *i.e.*, the positive accuracy is only 90 per cent at the inlet and 73 per cent at the mid-pelvis, while the negative accuracy lies between 98 and 100 per cent. C. The number of cases falling into a roentgenologic borderline group is too large at the mid-pelvis.

4. Despite these deficiencies, the results compare favorably with those obtained with the method of Chassar Moir or that of Caldwell, Moloy, and Steer (9).

5. Even with its shortcomings, the method is clinically useful; it succeeded in giving a definite and correct answer in all but 60 cases, thus reducing the number of clinically doubtful cases to approximately one-fifth.[4]

6. Technical improvements designed to overcome these deficiencies have been instituted; a preliminary survey suggests that it will be possible to increase the positive accuracy of predictions at the mid-pelvis by at least 10 per cent.

## SUMMARY

The correlation of roentgen cephalopelvimetry to obstetrical outcome has been determined by charting obstetrical results and roentgen measurements on graphs. It was found that the method of Ball produces roentgen predictions with an accuracy of 90 per cent or better except when mid-pelvic disproportion is present. In order to improve the accuracy of predictions and at the same time reduce the number of roentgenologic borderline cases, some technical improvements were adopted with promising results.

The graph method of charting measured cases made it possible to arrive at an optimum roentgenometric classification of cephalopelvic disproportion in which the Ball method gives the best results. This classification supersedes one published in a preliminary report, which of necessity possessed a wider safety margin (12).

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## APPENDIX

The argument has been advanced that the degree of correlation shown on Graph 4 might improve if stricter clinical criteria were used and that the percentage figures obtained merely reflect the particular type of obstetrical practice prevalent at Sloane Hospital. This is incorrect.

In order to test the universal applicability of the type of objective analysis employed in this study, we assumed—as an experiment—a hypothetical "barbarian" institution in which operative delivery for disproportion is denied all women. All normal deliveries remain then in their original positions on the graph. Of the abnormal ones, the five cases with the most unfavorable measurements were assumed to have resulted in stillbirth or manifest

[4] After eliminating cases with inadequate follow-up or incomplete radiographs from the total number studied.

brain injury and remained listed as abnormal. The other eleven abnormal outcomes were converted into "normal" deliveries. The result of such an extreme change in obstetric practice is an alteration of the roentgen classification. In order to obtain again the best possible correlation, it is now necessary to move the delineation of the high radiologic disproportion group from 220 c.c. to 250 c.c. This produces a smaller group of cases labeled as possessing high radiologic disproportion. The percentage accuracy, however, has remained unchanged. Previously it was 73 per cent (8 correct out of 11); now it is 72 per cent (5 correct out of 7).

In short, with a change in obstetrical practice or in evaluation of outcome the *roentgen classification* changes, but not the *degree of correlation*. The degree of positive accuracy is based solely upon the biological factors controlling the birth act and the mechanism of the particular x-ray method used. It is prescribed by nature and inherent in the method. Only its negative accuracy is dependent on definition of outcome, classification of measurements, and selection of patient material. An improvement of the positive accuracy can be brought about only by adopting a better method.

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## SUMARIO

### Correlación de la Céfalopelvimetría con el Resultado Obstétrico, con Referencia Especial a la Desproporción Radiológica

Se determinó la correlación de la céfalopelvimetría roentgenológica con el desenlace obstétrico trazando en gráficas los resultados obstétricos y las mediciones roentgenológicas. Descubrióse que el método de Ball da predicciones roentgenológicas que alcanzan una exactitud de 90 por ciento o más, excepto cuando existe desproporción mesopelviana. A fin de mejorar la exactitud de la predicción y al mismo tiempo reducir el número de casos limítrofes roentgenológicos, se adoptaron perfeccionamientos técnicos con resultados prometedores, figurando entre ellos la adopción de una vista ortométrica adicional dotada de una exactitud de más de 0.5 mm.

El método gráfico de trazar los casos medidos permitió llegar a una clasificación roentgenométrica óptima de la desproporción céfalopélvica en la que el método de Ball da los mejores resultados. Esta clasificación suplanta la publicada en una comunicación anterior, que poseía forzosamente un margen mayor de seguridad.

# Correction Factors for Tumor Dose in the Chest Cavity Due to Diminished Absorption and Scatter in Lung Tissue.

LILLIAN F. JACOBSON, M.A., F.A.C.R. (Assoc.), and ISABELLE S. KNAUER, M.A.

THE INVESTIGATION to be described here was undertaken to determine correction factors for the tumor dose of radiation in the lung and in the mediastinum, since the density of pulmonary tissue is so much less than that of muscle or water, on which the usual depth dose tables and isodose charts are based. Correction factors were determined from measurements obtained on a phantom man for 200-kv, 400-kv, and $Co^{60}$ radiations, for single and multiple ports, and for rotation therapy with $Co^{60}$.

## REVIEW OF LITERATURE

A number of investigators have attempted to find either a coefficient of absorption or a method of calculation to allow for the difference in absorption between muscle and lung. Failla (1) made measurements with radium and deflated lung tissue. Weatherwax and Robb (2) determined the depth dose for 200-kv roentgen rays in a human lung placed in a water phantom and inflated to various sizes. Quimby *et al.* (3) measured the depth doses in the chest of a cadaver for 200-kv radiation and published correction curves.

Nahon (4) investigated the transmission of 200-kv roentgen rays in the thorax and the abdomen of living subjects. He reported also (5) that depth-dose curves obtained in a plywood phantom with a density of 0.5 gm./c.c. were the same as those in the calf's thorax. Using this phantom he constructed isodose curves for the thorax for both multiple-field and rotational therapy.

Kornelsen (6) developed a method for calculating the dose for a centrally located lesion by the use of an effective coefficient of linear absorption obtained by measuring the entrance dose and the exit dose with a back-scattering medium.

Robbins and Meszaros (7) published curves of the transit dose rate for the chest and pelvis during rotation, based on measurements in a series of water phantoms. They also showed curves for three different patients.

## INTRODUCTION

The calculation of dosage in the lung is not a simple matter. When radiation is directed at a pulmonary lesion, it must penetrate the thoracic cage composed of muscle, bone, and sometimes fat, then pass through normal lung to carcinomatous lung of different density, and finally make its exit through normal lung and thoracic cage, without benefit of back-scattering material behind the body. Measurements made at autopsy showed the densities of carcinomas in collapsed lungs to vary from 0.86 gm./c.c. to 1.05 gm./c.c. The rib cage does not alter the dose appreciably, but the vertebral column does. The factors which cause the greatest variation in dosage in the 200-kv region are decreased absorption in lung tissue and decreased scatter, one sometimes balancing the other. Available depth-dose tables are based on a so-called infinite phantom, at least 30 × 30 × 30 cm. In treating the lung through fields of medium size, as for example 10 × 15 cm., there is a paucity of scattering medium on the side of the field which is being irradiated. Then, too, the scattering due to lung is much less than that from muscle, the relative density of the two tissues being about 1:3.

Masonite Presdwood of a density 1.0 gm./c.c. was used as a substitute for muscle, and cork of a density 0.27 gm./c.c. as a substitute for lung, which had a density of 0.32 gm./c.c. Absorption curves were made for a field 2 cm. in

[1] Accepted for publication in February 1956.

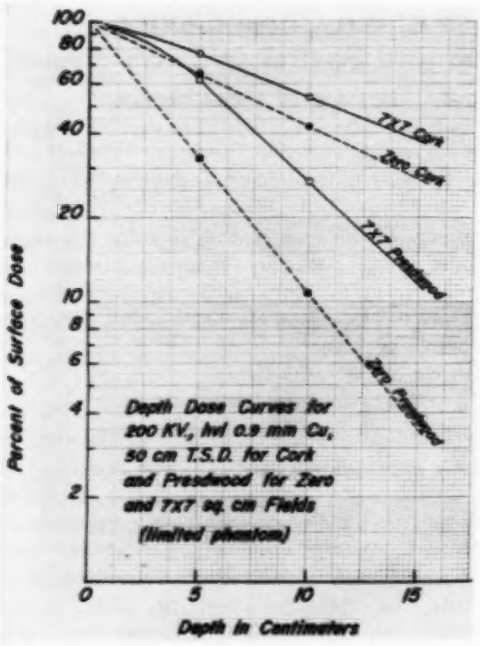



Fig. 1. Depth-dose curves for 200-kv roentgen rays, 50 cm. T.S.D., for cork and Presdwood, for zero and 7 × 7-cm. fields in a limited phantom.

diameter, for both 200-kv roentgen rays and for $Co^{60}$ (8). The points for Presdwood fell on the muscle curves. The points for cork were slightly higher than the corresponding points for lung. However, the values for both cork and Presdwood were found to correspond sufficiently well to those for lung and muscle, respectively, to permit the use of these materials for absorption measurements.

The depth doses of 200-kv roentgen rays in a limited phantom (13 × 25 × 18 cm.) for cork and Presdwood are shown in Figure 1. The difference between the curves for zero field and a 7 × 7-cm. field represents the part of the dose due to scatter. This difference is larger for Presdwood than for cork. In Figure 2 are shown the curves for $Co^{60}$. Here the difference between zero field and a 7 × 7-cm. field is much less than for 200 kv, showing that the scattering factor for supervoltage or $Co^{60}$ radiation plays a smaller part in the dose. Here too, as for 200 kv, the scatter for Presdwood is greater than for cork.

In fact, as we shall show later and as has also been found by Quimby *et al.* (3), the depth dose for 200 kv for the first 3 to 7 cm., in a chest cavity including lung, is less than that calculated from ordinary

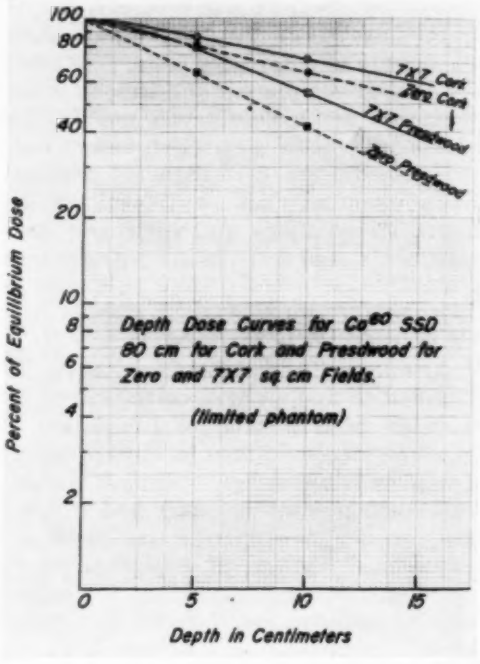



Fig. 2. Depth dose curves for $Co^{60}$ at 80 cm. S.S.D. for cork and Presdwood, for zero and 7 × 7-cm. fields in a limited phantom.

central-axis depth-dose tables. At greater depths the decrease in absorption in lung more than compensates for the decreased scatter, and the dose received at a given point is larger than that calculated from regular depth-dose tables.

For radiations in the supervoltage region, since scatter is not so important a consideration, a method of calculating dosage from coefficients of linear absorption was devised so that measured and calculated doses checked very well (8). Allowance was made for the inverse-square-law effect. In the 200-kv region, however, too many limiting factors had to be applied to make calculation feasible.

It would be more satisfactory if a simple correction factor could be obtained according to the location, number, and size of the ports. This correction factor is the number which, multiplied by the tumor dose, as found from central-axis depth-dose tables, will give the dose received at a given point. It is the ratio of the measured dose to the calculated dose.

### MEASUREMENTS ON A PHANTOM MAN

Measurements were taken on a phantom man made of Masonite Presdwood of unit density with cork lungs having a density of 0.27 gm./c.c. Each cross section corresponds to that of the typical man in Eycleshymer and Shoemaker's anatomical atlas.

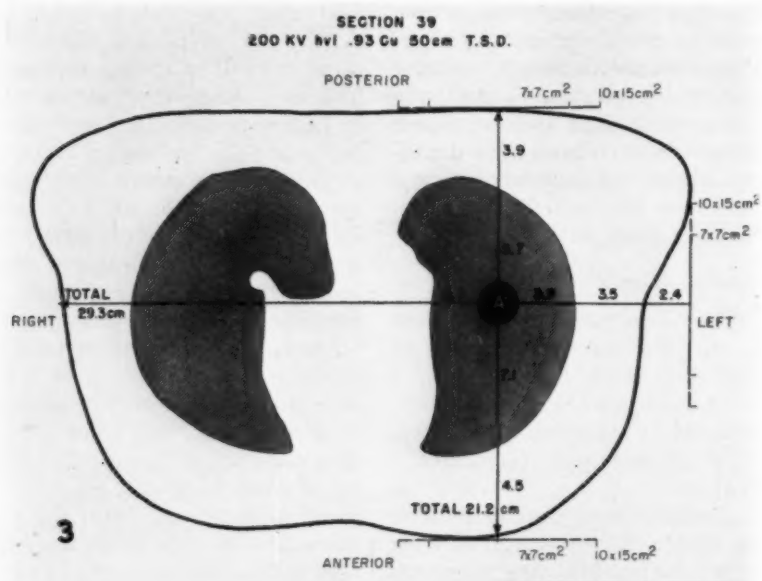
*Method:* Ionization measurements were made with either a Victoreen 25-r or 250-r chamber. The dose was measured at the center of the entrance port, of the "treated volume," and of the exit port. Great care was taken in lining up the radiation beam on the phantom layer, which was at the center of the field. The phantom was then built up so that it was, at all times, 30 cm. high. The ionization chamber fitted snugly into a Lucite plug which was pushed into a hole so that the chamber was at the center of the radiation field. Other holes in the phantom were filled, those in Presdwood with Lucite plugs, those in cork with cork plugs. The ionization chamber could be removed and reinserted, giving reproducible readings. The entrance dose for 200-kv roentgen rays and cobalt radiation was measured without the chamber being imbedded in the phantom. The exit dose was measured without any medium behind the chamber. The set-up with cobalt was easier because of a back-pointer device.

*200-kv Roentgen Rays:* The plan of treatment with 200-kv roentgen rays, through two opposing ports and a lateral port, each 10 × 15 cm. or 7 × 7 cm., is shown in Figure 3. If 100 r in air is delivered to the posterior port, then the dose as measured at Point A, at a depth of 9.6 cm., is 54.7 r, as shown in Table I. The dose calculated from central-axis depth-dose tables (9), which assume that there is a full scattering medium, is 54.5 r. The exit dose, at a depth of 21.2 cm., is 13.4 r as measured and 10.0 r as calculated. The correction factors are given in the last two columns of the table. These are: for Point A, 1.0, *i.e.*, measured and calculated doses are the same; for the exit dose 1.34, *i.e.*, the measured dose is 34 per cent higher than the calculated. Doses and correction factors are also given when anterior and lateral ports are used. Through the lateral port, Point A at 7.4 cm. depth receives a measured dose of 63.8 r, which is 7 per cent less than the calculated dose (correction factor 0.93). This reversal of what we would expect is due to the lower back-scatter from the cork, which decreases the dose more than the lessened absorption increases it. The correction factor for the total tumor dose, as delivered through the posterior and anterior ports, is 1.10, *i.e.*, the measured dose is 10 per cent higher than the calculated dose. When all three ports are used, the correction factor is 1.03.

Table I includes the figures for ports of 7 × 7 cm. For small ports, the ratio of the measured to the calculated dose differs from that when large ports are used, for here the scattering is less and absorption, therefore, plays a more important role. In all cases, the dose delivered is the same at each entrance port.

The two field sizes, 10 × 15 cm. and 7 × 7 cm., represent roughly the two extremes for entry ports. For three-port therapy to a lesion in the center of a lung, the range of correction is from 3 to 13 per cent; for two-port therapy the range is from 10 to 22 per cent for the larger and smaller fields respectively. Since the larger fields are more often used, the correction factor is 1.10 or less, for two- or three-port therapy.

For lung tumors centrally located the dose with 200-kv roentgen rays, if calculated from central-axis depth-dose tables, holds without any correction to within approximately 10 per cent.



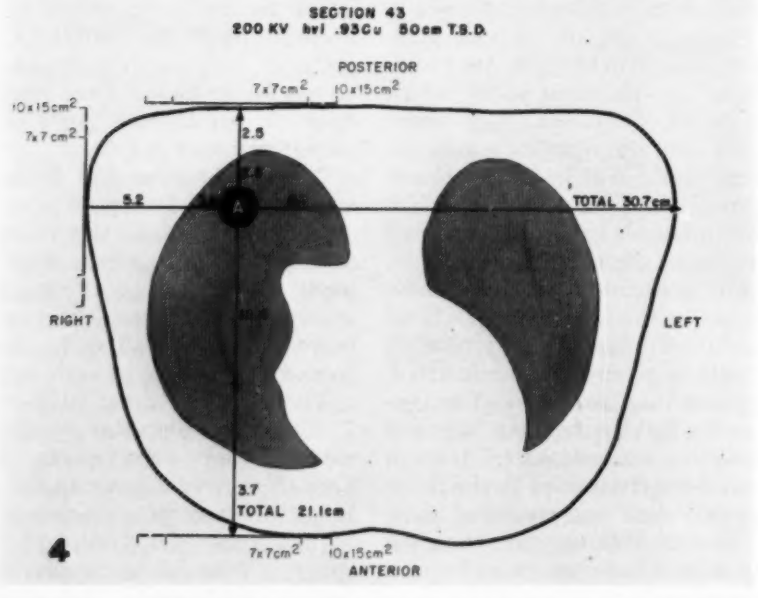




Fig. 3. Cross section of body through lung, showing the plan of treatment with 200 kv for a centrally located lesion.
Fig. 4. Plan of treatment with 200 kv for an asymmetrically located lesion.

The plan of treatment for an asymmetrically located lesion is shown in Figure 4, while Table II gives the doses at Point A and at the point of exit for 100 r in air at the entrance port. When treatment is given through the posterior port, which yields the highest dose to the lesion and is therefore the most economical port, the measured dose with a 10 × 15-cm. field, at a depth of 5 cm., is 77 r, while the calcu-

TABLE I: LESION IN CENTER OF LUNG: CORRECTION FACTOR AND DOSE TO LESION (POINT A) AND AT EXIT PORT PER 100 r IN AIR AT ENTRANCE PORT, FOR IRRADIATION THROUGH SINGLE AND COMBINED PORTS

(Three fields, 10 × 15 cm. and 7 × 7 cm., 200 kv, 50 cm. T.S.D., 0.94 mm. Cu h.v.l.)

| Port | Roentgens per 100 r in Air | | | | | | Correction Factor | | Ratio |
|---|---|---|---|---|---|---|---|---|---|
| | Point A | | | Exit | | | Ratio Meas./Calc. | | Meas. Exit / Meas. Point A |
| | Cm. Depth | Meas. | Calc. | Cm. Depth | Meas. | Calc. | Point A | Exit | |
| 10 × 15 cm. | | | | | | | | | |
| Post. | 9.6 | 54.7 | 54.5 | 21.2 | 13.4 | 10.0 | 1.00 | 1.34 | .25 |
| Ant. | 11.6 | 48.2 | 39.2 | 21.2 | 14.3 | 9.7 | 1.23 | 1.47 | .30 |
| Lat. | 7.4 | 63.8 | 68.0 | 29.3 | 4.8 | 2.8 | .93 | 1.71 | .075 |
| Post and ant. | | 51.5 | 46.9 | | | | 1.10 | | |
| All ports | | 55.5 | 53.9 | | | | 1.03 | | |
| 7 × 7 cm. | | | | | | | | | |
| Post. | 9.6 | 43.0 | 38.1 | 21.2 | 10.5 | 5.6 | 1.13 | 1.87 | .24 |
| Ant. | 11.6 | 36.9 | 27.6 | 21.2 | 10.5 | 5.7 | 1.34 | 1.84 | .28 |
| Lat. | 7.4 | 51.2 | 49.9 | 29.3 | 3.3 | 1.6 | 1.03 | 2.06 | .064 |
| Post. and ant. | | 40.0 | 32.9 | | | | 1.22 | | |
| All ports | | 43.7 | 38.5 | | | | 1.13 | | |

TABLE II: LESION AT PERIPHERY OF LUNG: CORRECTION FACTOR AND DOSE TO LESION (POINT A) AND AT EXIT PORT PER 100 r IN AIR AT ENTRANCE PORT, FOR IRRADIATION FROM SINGLE AND COMBINED PORTS

(Three fields, 10 × 15 cm. and 7 × 7 cm., 200 kv, 50 cm. T.S.D., h.v.l. 0.94 mm. Cu)

| Port | Roentgens per 100 r in Air | | | | | | Correction Factor | | Ratio |
|---|---|---|---|---|---|---|---|---|---|
| | Point A | | | Exit | | | Ratio Meas./Calc. | | Meas. Exit / Meas. Point A |
| | Cm. Depth | Meas. | Calc. | Cm. Depth | Meas. | Calc. | Point A | Exit | |
| 10 × 15 cm. | | | | | | | | | |
| Post. | 5.0 | 77.0 | 100 | 21.1 | 16.3 | 10.1 | .77 | 1.61 | .21 |
| Ant. | 16.1 | 33.7 | 19.7 | 21.1 | 16.2 | 9.7 | 1.71 | 1.67 | .48 |
| Lat. | 7.8 | 57.5 | 69.5 | 30.7 | 4.1 | 2.3 | .83 | 1.78 | .071 |
| Post. and ant. | | 55.9 | 59.9 | | | | .94 | | |
| All ports | | 56.1 | 63.1 | | | | .89 | | |
| 7 × 7 cm. | | | | | | | | | |
| Post. | 5.0 | 69.4 | 78.5 | 21.1 | 15.0 | 5.8 | .88 | 2.59 | .22 |
| Ant. | 16.1 | 23.3 | 12.3 | 21.1 | 13.5 | 5.5 | 2.14 | 2.46 | .51 |
| Lat. | 7.8 | 46.1 | 50.4 | 30.7 | 2.8 | 1.3 | .92 | 2.15 | .061 |
| Post. and ant. | | 47.9 | 45.4 | | | | 1.05 | | |
| All Ports | | 47.3 | 47.1 | | | | 1.01 | | |

lated dose is 100 r. This gives a ratio or correction factor of 0.77. In other words, the measured dose is 23 per cent less than the calculated dose, and if therapy is given through this port only, the correction should be made on that basis.

When irradiation is administered through an anterior 10 × 15-cm. port, the correction factor is 1.71, *i.e.*, the measured dose is 71 per cent greater than the calculated. If, however, both anterior and posterior ports are used, the measured dose is 94 per cent of the calculated; with all three ports, the measured dose is 89 per cent of the calculated. Six and 11 per cent more radiation would therefore be required, respectively, to attain the desired dose.

For 7 × 7-cm. fields the results are slightly different. The correction factor when an anterior and a posterior port are used is 1.05; when all three ports are employed, 1.01.

For a lesion located at the periphery of a lung, therefore, if one is using a single port, especially the best port, 10 to 20 per cent radiation will have to be added to attain the calculated dose. If anterior and posterior ports or all three ports are used, the addition will be 0 to 11 per cent, according

TABLE III: LESION IN CENTER OF MEDIASTINUM: CORRECTION FACTOR AND DOSE TO LESION (POINT A) AND AT EXIT PORT PER 100 r AT ENTRANCE PORT, FOR IRRADIATION THROUGH SINGLE AND COMBINED PORTS

(Six fields 8 × 15 cm. and 7 × 7 cm., 200 kv, 50 cm. T.S.D., h.v.l. 0.94 mm. Cu)

| Port | Roentgens per 100 r in Air | | | | | | Correction Factor | | Ratio |
|---|---|---|---|---|---|---|---|---|---|
| | Point A | | | Exit | | | Ratio Meas./Calc. | | Meas. Exit / Meas. Point A |
| | Cm. Depth | Meas. | Calc. | Cm. Depth | Meas. | Calc. | Point A | Exit | |
| 8 × 15 cm. | | | | | | | | | |
| Ant. | 11.9 | 32.6 | 31.7 | 22.0 | 4.8 | 6.7 | 1.03 | .72 | .147 |
| Post. | 10.1 | 40.8 | 43.7 | 22.0 | 5.7 | 7.3 | .94 | .78 | .140 |
| L. post. obl. | 15.2 | 30.7 | 19.0 | 29.4 | 3.5 | 2.2 | 1.61 | 1.59 | .114 |
| L. ant. obl. | 14.2 | 23.8 | 22.8 | 28.9 | 2.9 | 2.4 | 1.04 | 1.21 | .122 |
| Rt. ant. obl. | 14.2 | 29.1 | 22.8 | 29.4 | 3.5 | 2.2 | 1.28 | 1.59 | .120 |
| Rt. post. obl. | 14.7 | 38.0 | 20.6 | 28.9 | 3.2 | 2.4 | 1.84 | 1.33 | .084 |
| Ant. and Post. | | 36.7 | 37.7 | | | | .97 | | |
| All Ports | | 32.5 | 26.8 | | | | 1.21 | | |
| 7 × 7 cm. | | | | | | | | | |
| Ant. | 11.9 | 26.4 | 27.3 | 22.0 | 3.6 | 4.6 | .97 | .79 | .136 |
| Post | 10.1 | 32.5 | 34.8 | 22.0 | 3.6 | 5.0 | .93 | .72 | .110 |
| L. post. obl. | 15.2 | 26.0 | 13.8 | 29.4 | 2.4 | 1.5 | 1.88 | 1.60 | .093 |
| L. ant. obl. | 14.2 | 18.2 | 16.7 | 28.9 | 2.3 | 1.6 | 1.09 | 1.44 | .126 |
| Rt. ant. obl. | 14.2 | 24.4 | 16.7 | 29.4 | 2.4 | 1.5 | 1.46 | 1.60 | .098 |
| Rt. post. obl. | 14.7 | 31.1 | 15.1 | 28.9 | 2.9 | 1.5 | 2.06 | 1.93 | .093 |
| Ant. and Post. | | 29.5 | 31.1 | | | | .95 | | |
| All Ports | | 26.4 | 20.8 | | | | 1.27 | | |

to the size of the ports. If no correction is made, the actual dose will be within 10 per cent of the calculated dose.

For a lesion located in the center of the mediastinum (Point A, Fig. 5), the dose from each port and the combined dose are shown in Table III. Here the measured and calculated doses for each port are approximately equal. This is to be expected, since the radiation is traversing mostly unit density material. When, however, oblique fields are included, so that the radiation passes through lung tissue (cork), the correction factor is appreciable. With six fields of 8 × 15 cm., the correction factor is 1.21; for an equal number of 7 × 7 cm., 1.27. Here, then, the measured dose is approximately 25 per cent greater than the calculated dose.

Exit doses are sometimes used as a measure of the dose to the tumor (6, 7). This method may hold for centrally located lesions (6) with material of other than unit density symmetrically placed about the center. If the exit dose is to be used as a measure of the dose to the center of the tumor, then there should exist, within experimental error, a fixed ratio between the two. The last column of Table III shows that this ratio has a spread from 0.084 to 0.147. The exit and tumor doses depend on the thickness of the body and on the density of the material traversed by the radiation. An examination of two opposing ports, the left anterior oblique and the right posterior oblique, for 8 × 15-cm. fields shows for the former a tumor dose of 23.8 r and an exit dose of 2.9 r, giving a ratio of exit to tumor dose of 0.122; while for radiation from the right posterior oblique port, the tumor dose is 38.0 r and the exit dose 3.2 r, yielding a ratio of 0.084.

As is shown in Figure 5, the radiation from the first port goes, for the most part, through "mediastinal tissues," while that from the second port traverses more "lung" tissue, with its lesser density, absorption, and scatter, giving a larger dose. The exit dose also varies according to whether the less dense material is at the beginning or at the end of its path. Results with 7 × 7-cm. fields are similar. Therefore, for beam-direction therapy, where the material surrounding the lesion is not uniform (lung on one side, mediastinal tissue on the other), the exit dose cannot be used as a measure of the tumor dose. If, however, the "lung" tissue is more or

less uniform on both entrance and exit sides, of the tumor, as for the right anterior oblique port and its opposite, the left posterior oblique port, then the exit dose may constitute a satisfactory measure of the tumor dose. For these ports be used as a measure of the tumor dose.

*400-kv Roentgen Rays:* Roentgen rays from a 400-kv machine with 4.9 mm. Cu h.v.l. were investigated at a focus-skin distance of 70 cm. The air dose was measured and the surface dose was calcu-

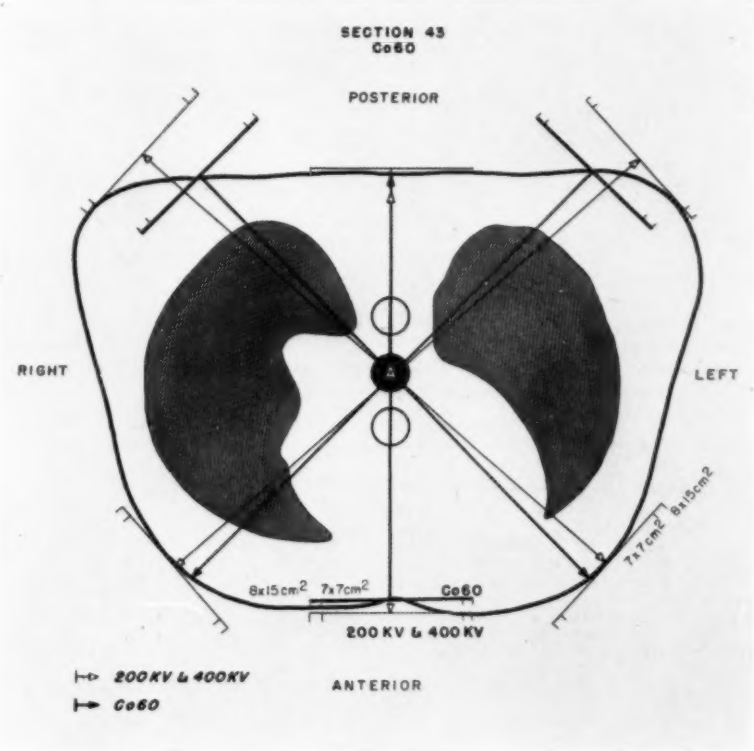



Fig. 5. Plan of treatment for a centrally located mediastinal lesion irradiated through opposing ports and through six ports, by 200-kv and 400-kv roentgen rays, and through three ports by $Co^{60}$.

the ratio of the exit dose to the tumor dose is 0.120 and 0.114 respectively, which is within experimental error. With 7 × 7-cm. ports the ratios are 0.098 for the right anterior oblique port, and 0.093 for the left posterior oblique port.

The last column of Table II for 10 × 15-cm. fields and an asymmetrically located lesion (Fig. 4), gives the following ratios of exit to tumor dose: (*a*) for the anterior port 0.48; (*b*) for the posterior port 0.21; (*c*) for the lateral port 0.071. Here then, as would be expected, the exit dose cannot lated from it by use of the back-scatter factor. The doses at the given point and at the exit were measured under the following conditions: (*a*) when Point A was located centrally in the lung, with three 10 × 15-cm. ports and three 7 × 7-cm. ports, as in Figure 3; (*b*) when Point A was at the periphery of the lung, as in Figure 4; (*c*) when the given point was in the center of the mediastinal area, as in Figure 5. The results are summarized in Tables IV–VI.

For a central "lung" lesion, as in Figure 3, with two opposing 10 × 15-cm. ports,

TABLE IV: LESION IN CENTER OF LUNG: CORRECTION FACTOR AND DOSE TO LESION (POINT A) AND AT EXIT PORT PER 100 r IN AIR AT ENTRANCE PORT, FOR IRRADIATION THROUGH SINGLE AND COMBINED PORTS

(Three fields, 10 × 15 cm. and 7 × 7 cm., 400 kv, 70 cm. T.S.D., h.v.l. 4.9 mm. Cu)

| Port | Roentgens per 100 r in air | | | | | | Correction Factor | | Ratio |
|---|---|---|---|---|---|---|---|---|---|
| | Cm. Depth | Point A | | Cm. Depth | Exit | | Ratio Meas./Calc. | | Meas. Exit / Meas. Point A |
| | | Meas. | Calc. | | Meas. | Calc. | Point A | Exit | |
| 10 × 15 cm. | | | | | | | | | |
| Post. | 9.6 | 62.5 | 55.9 | 21.2 | 20.6 | 14.0 | 1.12 | 1.47 | .33 |
| Ant. | 11.6 | 56.6 | 44.2 | 21.2 | 21.3 | 14.0 | 1.28 | 1.52 | .38 |
| Lat. | 7.4 | 70.6 | 72.0 | 29.3 | 8.8 | | .98 | | .12 |
| Post. and ant. | | 59.6 | 50.1 | | | | 1.19 | | |
| All ports | | 63.2 | 57.4 | | | | 1.10 | | |
| 7 × 7 cm. | | | | | | | | | |
| Post. | 9.6 | 49.3 | 43.3 | 21.2 | 15.4 | 9.6 | 1.14 | 1.60 | .31 |
| Ant. | 11.6 | 45.6 | 33.1 | 21.2 | 16.2 | 9.6 | 1.38 | 1.69 | .35 |
| Lat. | 7.4 | 58.8 | 59.5 | 29.3 | 6.6 | | .99 | | .11 |
| Post. and ant. | | 47.5 | 38.2 | | | | 1.24 | | |
| All ports | | 51.2 | 45.3 | | | | 1.13 | | |

TABLE V: LESION AT PERIPHERY OF LUNG: CORRECTION FACTOR AND DOSE TO LESION (POINT A) AND EXIT PORT PER 100 r IN AIR AT ENTRANCE PORT, FOR IRRADIATION THROUGH SINGLE AND COMBINED PORTS

(Three fields, 10 × 15 cm. and 7 × 7 cm., 400 kv, 70 cm. T.S.D., h.v.l. 4.9 mm. Cu)

| Port | Roentgens per 100 r in air | | | | | | Correction Factor | | Ratio |
|---|---|---|---|---|---|---|---|---|---|
| | Cm. Depth | Point A | | Cm. Depth | Exit | | Ratio Meas./Calc. | | Meas. Exit / Meas. Point A |
| | | Meas. | Calc. | | Meas. | Calc. | Point A | Exit | |
| 10 × 15 cm. | | | | | | | | | |
| Post. | 5.0 | 89.0 | 93.5 | 21.1 | 23.5 | 14.7 | .95 | 1.60 | .26 |
| Ant. | 16.1 | 43.3 | 25.8 | 21.1 | 24.2 | 14.7 | 1.68 | 1.65 | .56 |
| Lat. | 7.8 | 65.4 | 69.0 | 30.7 | 7.4 | | .95 | | .11 |
| Post and ant. | | 66.1 | 59.7 | | | | 1.11 | | |
| All ports | | 65.9 | 62.8 | | | | 1.05 | | |
| 7 × 7 cm. | | | | | | | | | |
| Post. | 5.0 | 74.2 | 80.2 | 21.1 | 19.8 | 9.5 | .93 | 2.08 | .27 |
| Ant. | 16.1 | 32.4 | 19.1 | 21.1 | 19.1 | 9.5 | 1.69 | 2.01 | .59 |
| Lat. | 7.8 | 52.9 | 55.8 | 30.7 | 5.9 | | .95 | | .11 |
| Post and ant. | | 53.3 | 49.7 | | | | 1.07 | | |
| All ports | | 53.2 | 51.7 | | | | 1.03 | | |

the measured dose is 1.19 times the calculated dose; for two 7 × 7-cm. ports 1.24; for three ports, with larger fields 1.10 and with smaller fields 1.13. The measured dose is approximately 15 per cent higher than the calculated one if more weight is given to the larger field.

When the lesion is situated at the periphery of the lung, as in Figure 4, the ratios are: for anterior and posterior 10 × 15-cm. ports, 1.11, and for 7 × 7-cm. ports, 1.07. For the three larger ports the correction factor is 1.05; for the three smaller, 1.03. No correction is necessary under these conditions, and the same is true if the two most economical ports, the posterior and lateral, are used. Nor is any correction required if the lesion is located at the center of the mediastinum and treated through two opposing ports. If, however, treatment is through six 8 × 15-cm. ports, the measured dose is 22 per cent greater than the calculated. If six 7 × 7-cm. ports are used, the measured dose is 18 per cent greater than the calculated. Therefore, the correction factor is approximately 1.20.

*Cobalt 60:* With gamma radiation from

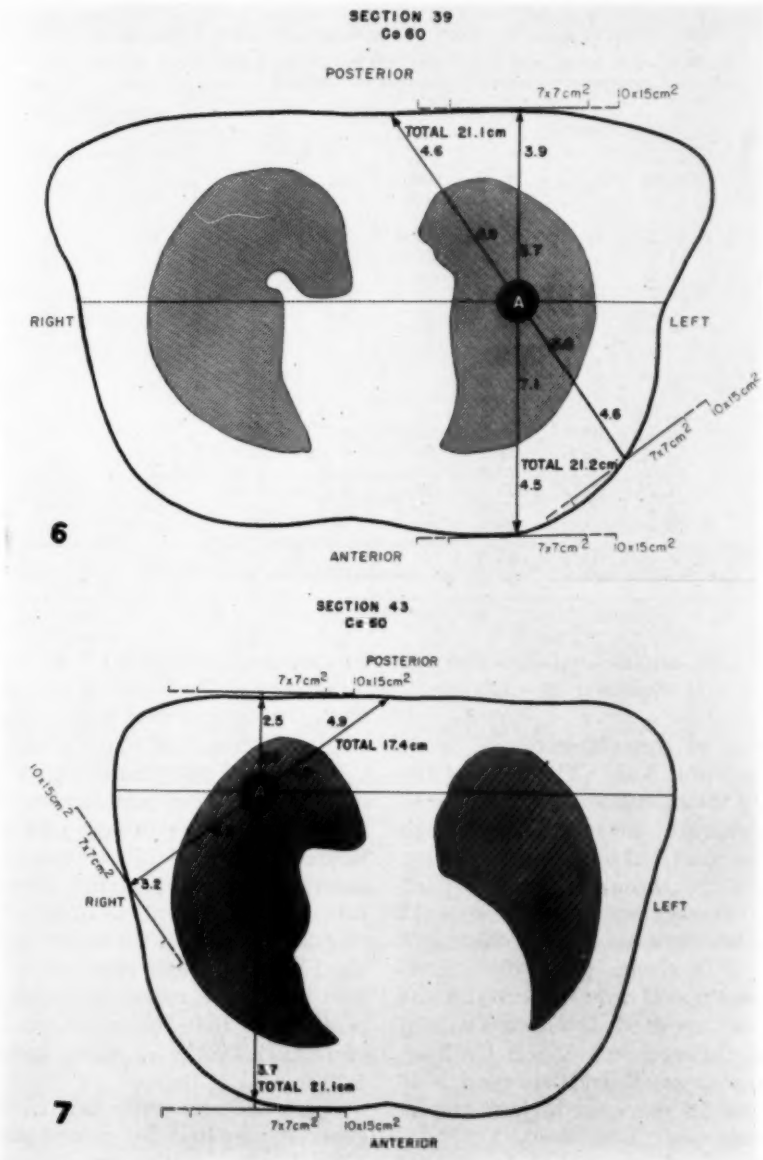



Fig. 6. Plan of treatment with $Co^{60}$ for a lesion located in the center of a lung (Section 39). Ordinarily directly opposing ports are not used.
Fig. 7. Plan of treatment with $Co^{60}$ for an asymmetrically located lesion (Section 43).

radioactive cobalt or with supervoltage roentgen rays, the component of the dose due to scatter is less important than with 200- or 400-kv roentgen rays. The plan of treatment through three ports for a lesion located in the center of a lung is shown in Figure 6. One would not ordinarily treat through directly opposing ports but, because they are sometimes used, they were incorporated in the plan of treatment. A lateral oblique port is used instead of a true lateral, for with the aid of a back

TABLE VI: LESION IN CENTER OF MEDIASTINUM: CORRECTION FACTOR AND DOSE TO LESION (POINT A) AND AN EXIT PORT PER 100 r IN AIR AT ENTRANCE PORT, FOR IRRADIATION THROUGH SINGLE AND COMBINED PORTS

(Six fields, 8 × 15 cm. and 7 × 7 cm., 400 kv, 70 cm. T.S.D., h.v.l. 4.9 mm. Cu)

| Port | Roentgens per 100 r in air | | | | | | Correction Factor | | Ratio |
|---|---|---|---|---|---|---|---|---|---|
| | Cm. Depth | Point A | | Cm. Depth | Exit | | Ratio Meas./Calc. | | Meas. Exit |
| | | Meas. | Calc. | | Meas. | Calc. | Point A | Exit | Meas. Point A |
| 8 × 15 cm. | | | | | | | | | |
| Post. | 10.1 | 46.2 | 47.7 | 22.0 | 8.2 | 11.2 | .97 | .73 | .18 |
| Ant. | 11.9 | 42.5 | 38.0 | 22.0 | 8.2 | 11.2 | 1.12 | .73 | .19 |
| L. post. obl. | 15.2 | 40.2 | 26.1 | 29.4 | 6.7 | 4.5 | 1.54 | 1.49 | .17 |
| L. ant. obl. | 14.2 | 30.5 | 29.1 | 28.9 | 6.0 | 4.5 | 1.05 | 1.33 | .20 |
| Rt. ant. obl. | 14.2 | 37.3 | 29.1 | 29.4 | 6.7 | 4.5 | 1.28 | 1.49 | .18 |
| Rt. post. obl. | 14.7 | 44.0 | 27.6 | 28.9 | 6.0 | 4.5 | 1.59 | 1.33 | .14 |
| Post. and ant. | | 44.4 | 42.9 | | | | 1.03 | | |
| All ports | | 40.1 | 32.9 | | | | 1.22 | | |
| 7 × 7 cm. | | | | | | | | | |
| Post. | 10.1 | 37.3 | 40.3 | 22.0 | 6.7 | 8.2 | .93 | .82 | .18 |
| Ant. | 11.9 | 32.8 | 32.1 | 22.0 | 6.7 | 8.2 | 1.02 | .82 | .20 |
| L. post. obl. | 15.2 | 32.8 | 20.9 | 29.4 | 4.5 | 3.0 | 1.57 | 1.50 | .14 |
| L. ant. obl. | 14.2 | 23.9 | 23.9 | 28.9 | 3.7 | 3.4 | 1.0 | 1.09 | .15 |
| Rt. ant. obl. | 14.2 | 29.8 | 23.9 | 29.4 | 4.5 | 3.0 | 1.24 | 1.50 | .15 |
| Rt. post. obl. | 14.7 | 35.8 | 22.4 | 28.9 | 3.7 | 3.4 | 1.60 | 1.09 | .10 |
| Post. and ant. | | 35.1 | 36.2 | | | | .97 | | |
| All ports | | 32.1 | 27.2 | | | | 1.18 | | |

pointer and cast, any desired direction can be obtained and repeated at each treatment.

The results of this phase of the study are given in Table VII. The ratio of the measured to the calculated dose for the 10 × 15-cm. fields are: for treatment through the posterior port, 1.15; through the anterior port, 1.17; through the lateral port, 1.03. The average measured dose is 12 per cent higher than the average calculated dose. For 7 × 7-cm. ports the corrections are similar. If only the anterior and posterior ports are used, as with the patient lying down, the measured dose in the lung, whether large or small fields are used, is 16 per cent and 18 per cent higher, respectively, than the calculated dose.

If the lesion is located at the periphery of the lung, as in Figure 7, the results are those given in Table VIII. For two- or three-port therapy, the measured dose is approximately 15 per cent higher than the calculated dose.

In treating a lesion in the mediastinal region (Figure 5) through the mediastinum, with two 8 × 15-cm. ports, the measured dose is 7 per cent higher than the calculated dose; with two 7 × 7-cm. ports, 6 per cent. Therefore, if no correction is made, the actual dose differs from the calculated by less than 10 per cent.

Because of the greater depth dose with cobalt, only three ports are needed to get an adequate uniform dose into a centrally located lesion, as in the esophagus. An anterior and two posterior lateral oblique fields might be used, as in Figure 5. The results with such a set-up are given in Table IX. For these three ports and both field sizes, the measured value is 23 per cent greater than the calculated value. The correction factor is then approximately 1.20 to 1.25.

With $Co^{60}$, centrally located lesions are generally treated by a rotation technic. The air dose at the axis of rotation was measured with the platform rotating, for a 10 × 15-cm. and a 7 × 7-cm. field. These doses are not the same for our cobalt unit. The dose was measured in the phantom with the ionization chamber (*a*) in the hole A, at the center of the lung (Figure 6); (*b*) at the periphery of the lung (Figure 7); (*c*) at the center of the mediastinal region, as in Figure 5. The

TABLE VII: LESION IN CENTER OF LUNG: CORRECTION FACTOR AND DOSE TO LESION (POINT A) AND AT EXIT PORT PER 100 r IN AIR AT ENTRANCE PORT, FOR IRRADIATION THROUGH SINGLE AND COMBINED PORTS

(Three fields, 10 × 15 cm. and 7 × 7 cm. $Co^{60}$. S.S.D. 80 cm.)

| Port | Roentgens per 100 r in air | | | | | | Correction Factor | | Ratio |
|---|---|---|---|---|---|---|---|---|---|
| | Point A | | | Exit | | | Ratio Meas./Calc. | | Meas. Exit / Meas. Point A |
| | Cm. Depth | Meas. | Calc. | Cm. Depth | Meas. | Calc. | Point A | Exit | |
| 10 × 15 cm. | | | | | | | | | |
| Post. | 9.6 | 70.1 | 60.7 | 21.2 | 38.4 | 27.6 | 1.15 | 1.39 | .55 |
| Ant. | 11.6 | 64.5 | 55.1 | 21.2 | 39.7 | 27.5 | 1.17 | 1.44 | .62 |
| Lat. obl. | 9.6 | 62.6 | 60.7 | 21.1 | 37.8 | 27.6 | 1.03 | 1.37 | .60 |
| Ant. and post. | | 67.3 | 57.8 | | | | 1.16 | | |
| All ports | | 65.7 | 58.8 | | | | 1.12 | | |
| 7 × 7 cm. | | | | | | | | | |
| Post. | 9.6 | 64.5 | 56.7 | 21.2 | 33.6 | 23.5 | 1.14 | 1.43 | .52 |
| Ant. | 11.6 | 60.1 | 48.5 | 21.2 | 35.6 | 23.5 | 1.24 | 1.51 | .59 |
| Lat. obl. | 9.6 | 64.0 | 56.7 | 21.1 | 34.1 | 23.6 | 1.13 | 1.45 | .53 |
| Ant. and post. | | 62.3 | 52.6 | | | | 1.18 | | |
| All ports | | 62.9 | 54.0 | | | | 1.16 | | |

TABLE VIII: LESION AT PERIPHERY OF LUNG: CORRECTION FACTOR AND DOSE TO LESION (POINT A) AND AT EXIT PORT PER 100 r IN AIR AT ENTRANCE PORT, FOR IRRADIATION THROUGH SINGLE AND COMBINED PORTS

(Three fields, 10 × 15 cm. and 7 × 7 cm. $Co^{60}$. S.S.D. 80 cm.)

| Port | Roentgens per 100 r in air | | | | | | Correction Factor | | Ratio |
|---|---|---|---|---|---|---|---|---|---|
| | Point A | | | Exit | | | Ratio Meas./Calc. | | Meas. Exit / Meas. Point A |
| | Cm. Depth | Meas. | Calc. | Cm. Depth | Meas. | Calc. | Point A | Exit | |
| 10 × 15 cm. | | | | | | | | | |
| Post. | 5.0 | 84.8 | 82.5 | 21.1 | 41.8 | 27.9 | 1.03 | 1.50 | .49 |
| Ant. | 16.1 | 54.0 | 39.0 | 21.1 | 41.8 | 27.9 | 1.38 | 1.50 | .78 |
| Lat. obl. | 8.5 | 73.0 | 65.5 | 17.4 | 42.2 | 35.8 | 1.11 | 1.18 | .58 |
| Ant. and post. | | 69.4 | 60.8 | | | | 1.14 | | |
| All ports | | 70.6 | 62.3 | | | | 1.14 | | |
| 7 × 7 cm. | | | | | | | | | |
| Post. | 5.0 | 82.0 | 79.5 | 21.1 | 40.0 | 23.9 | 1.03 | 1.67 | .49 |
| Ant. | 16.1 | 50.8 | 34.7 | 21.1 | 38.6 | 23.9 | 1.47 | 1.61 | .76 |
| Lat. obl. | 8.5 | 69.4 | 62.0 | 17.4 | 39.6 | 31.8 | 1.12 | 1.24 | .57 |
| Ant. and post. | | 66.4 | 57.1 | | | | 1.16 | | |
| All ports | | 67.4 | 58.7 | | | | 1.15 | | |

TABLE IX: LESION IN CENTER OF MEDIASTINUM: CORRECTION FACTOR AND DOSE TO LESION (POINT A) AND AT EXIT PORT PER 100 r IN AIR AT ENTRANCE PORT, FOR IRRADIATION THROUGH SINGLE AND COMBINED PORTS

(Three fields, 8 × 15 cm. and 7 × 7 cm. $Co^{60}$. S.S.D. 80 cm.)

| Port | Roentgens per 100 r in air | | | | | | Correction Factor | | Ratio |
|---|---|---|---|---|---|---|---|---|---|
| | Point A | | | Exit | | | Ratio Meas /Calc. | | Meas. Exit / Meas. Point A |
| | Cm. Depth | Meas. | Calc. | Cm. Depth | Meas. | Calc. | Point A | Exit | |
| 8 × 15 cm. | | | | | | | | | |
| Ant. | 11.9 | 54.8 | 50.2 | 22.0 | 23.7 | 24.6 | 1.09 | .96 | .43 |
| L. post. obl. | 14.2 | 55.3 | 42.8 | 28.2 | 20.9 | 15.8 | 1.29 | 1.32 | .38 |
| Rt. post. obl. | 13.8 | 59.0 | 44.2 | 28.0 | 20.0 | 16.3 | 1.33 | 1.22 | .34 |
| All ports | | 56.4 | 45.7 | | | | 1.23 | | |
| 7 × 7 cm. | | | | | | | | | |
| Ant. | 11.9 | 50.7 | 47.8 | 22.0 | 21.0 | 21.9 | 1.06 | .96 | .42 |
| L. post. obl. | 14.2 | 52.2 | 40.2 | 28.2 | 19.1 | 13.9 | 1.30 | 1.37 | .37 |
| Rt. post. obl. | 13.8 | 55.5 | 41.0 | 28.0 | 17.7 | 14.3 | 1.35 | 1.24 | .32 |
| All ports | | 52.8 | 43.0 | | | | 1.23 | | |

TABLE X: CORRECTION FACTOR AND DOSE AT AXIS OF ROTATION, POINT A, PER 100 r IN AIR AT SAME POINT, FOR 10 × 15 CM. AND 7 × 7 CM. FIELDS

($CO^{60}$ at source axis distance, S.A.D., 115 cm. Fig. 5)

| Section | Location of Point A | 10 × 15 cm. | | | 7 × 7 cm. | | |
|---|---|---|---|---|---|---|---|
| | | Meas. | Calc. | Cor. Factor Meas./Calc. | Meas. | Calc. | Cor. Factor Meas./Calc. |
| 39 | Center of lung | 75.4 | 64.0 | 1.18 | 72.3 | 59.0 | 1.22 |
| 43 | Periphery of lung | 74.3 | 65.0 | 1.14 | 72.3 | 60.0 | 1.20 |
| 43 | Center of mediastinum | 71.3 | 61.0 | 1.17 | 67.8 | 55.6 | 1.21 |
| | | *Presdwood Replaced Cork* | | | | | |
| 39 | Center of lung | 69.2 | 64.0 | 1.08 | 64.5 | 59.0 | 1.09 |
| 43 | Center of mediastinum | 65.0 | 60.9 | 1.07 | 59.0 | 56.7 | 1.04 |

TABLE XI: COMPARISON BETWEEN MEASURED AND CALCULATED EXIT DOSES ON PATIENTS FOR $CO^{60}$ (S.S.D. 80 CM.)

| Patient | Port | Cm. | Exit Dose r/min. | | Meas./-Calc. |
|---|---|---|---|---|---|
| | | | Meas. | Calc. | |
| K. F. | A. Obl. | 20.8 | 8.2 | 7.3 | 1.12 |
| | L. Obl. | 28.4 | 5.4 | 4.3 | 1.25 |
| | P. Obl. | 21.8 | 5.4 | 6.6 | .82 |
| J. G. | A. Obl. | 26.9 | 5.5 | 4.4 | 1.25 |
| | P. Obl. | 29.8 | 3.6 | 3.7 | .97 |
| | L. Obl. | 32.7 | 3.5 | 3.0 | 1.16 |
| L. B. | Ant. | 26.6 | 4.7 | 4.6 | 1.02 |
| | L. Obl. | 34.9 | 3.8 | 2.5 | 1.52 |
| | Post. | 27.7 | 3.7 | 4.3 | .86 |

results are shown in Table X. The measured doses for the 10 × 15-cm. fields are 14 to 18 per cent higher than the calculated, and for the 7 × 7-cm. field 20 to 22 per cent higher than the calculated. A correction factor of 1.15 could be used for the larger field and 1.20 for the smaller one.

The cork section of each slab was removed and replaced by Presdwood, and the dose measured for Section 39 and for the mediastinal hole of Section 43. The measured and calculated doses differed by 4 to 9 per cent. The reason for this difference is not obvious.

The results with $Co^{60}$ gamma radiation can be approximated thus: The correction factor with fixed-beam therapy, when two or three ports of average size are used, (except two opposing mediastinal ports), and with rotation therapy to a lesion located anywhere in the chest cavity, is 1.15. No correction is necessary for two opposing ports through the mediastinum.

The ratio of the measured exit dose to the dose measured at the point of interest is shown in the last column of Tables VII, VIII, and IX. When the lesion is centrally located in the lung (Figure 6), the ratio varies from 0.52 to 0.60; in the mediastinum (Figure 5), from 0.32 to 0.43. When the lesion is located asymmetrically in the lung (Table VIII; Figure 7), the exit dose is no indication of what the tumor receives and the ratio varies from 0.49 to 0.78.

The exit dose was measured and calculated on a number of patients. The results in three of these are given in Table XI. The thickness through which the radiation passed is indicated in column 3. The ratio of the measured to the calculated exit dose differs according to the thickness of lung, vertebral column, and mediastinum traversed by the radiation. For an anterior port on patient L. B. it was 1.02; for other patients the ratio was almost unity. For the lateral oblique port, where more lung tissue lies in the path of the beam, the ratio is 1.52 for patient L. B. and 1.25 for patients K. F. and J. G. For a posterior port, the ratio was generally less than one; if the radiation passed through the vertebral column, as in patient L. B., the ratio was 0.86. The exit dose, as calculated from central-axis depth-dose tables may be off by +20 to −50 per cent, according to measurements on these patients. The exact dose, however, is not too important except where entrance and exit fields overlap.

## DISCUSSION

The correction factors based on experimental work hold for patients of average size—anteroposterior dimension 21 cm., lateral 29 cm. Where the patient is heavier or lighter, these correction factors may not hold. It would seem better, however, to make the average correction than not to correct at all.

The density of normal lung is a moot question. The tumor, having a density greater than that of pulmonary tissue, may occupy a large portion of the lung. The dose received may differ, therefore, from the corrected dose. It is not necessarily less, especially in the lower voltage region, where scatter may be a more important factor than absorption. It would be preferable, until more data are obtained, to neglect the exceptions and use the average correction factors which apply to the type of therapy being used.

In some of the tables the calculated exit doses for the same thickness of phantom differ. This is due to a difference in the surface dose between the two positions, for 100 r in air.

## RECOMMENDATIONS

For *200-kv roentgen rays* corrections should be made (or omitted) as follows:

1. For tumors located anywhere in the lung, if no correction is made and treatment is given through either two or three ports, the tumor dose will be correct to ±10 per cent.
2. If the tumor is located in the mediastinum and treated through two opposing ports, no correction need be made.
3. If the tumor is located in the mediastinum and treated through six ports, the correction factor is 1.25.

For *400-kv roentgen rays:*

1. No correction is necessary (*a*) for an asymmetrically located lesion of the lung treated through either two or three ports or (*b*) for a mediastinal lesion treated through two opposing ports, through the mediastinum.
2. For two- or three-port therapy, if the lesion is located in the central portion of a lung, the correction factor is 1.15.
3. For a mediastinal lesion treated through six ports the correction factor is 1.20. For convenience 1.15 may be used.

For *$Co^{60}$ gamma radiation:*

1. The correction factor is 1.15 for rotation therapy or two or three fixed ports, with the lesion anywhere in the chest cavity except the mediastinum.
2. No correction is necessary for two opposing ports through the mediastinum.
3. For a mediastinal lesion treated through three ports the correction factor is 1.20. Here again a correction factor of 1.15 may be used.

## SUMMARY

1. Depth dose curves in cork and Presdwood for a limited phantom with a "zero" field and a 7 × 7-cm. field for 200-kv and $Co^{60}$ radiation are plotted.

2. Correction factors were found experimentally for irradiation with 200-kv and 400-kv roentgen rays through fixed ports, and for $Co^{60}$ gamma radiation through fixed ports and with rotation. Each factor when multiplied by the tumor dose as calculated from depth-dose tables gives the dose received at the lung or mediastinal lesion.

NOTE: We wish to thank the members of the physics department of Memorial Hospital for making the phantom man.

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SUMARIO

**Los Factores de Corrección para la Dosis Tumor en la Cavidad Torácica Debido a la Menor Absorción y Dispersión en el Tejido Pulmonar**

Se trazan aquí curvas de la dosis a profundidad en corcho y en "Presdwood" para un fantasma limitado con un campo de "cero" y un campo de 7 × 7 cm. para radiación de 200 kv y de $Co^{60}$.

Se determinaron experimentalmente los factores de corrección para irradiación con rayos X de 200 kv y 400 kv a través de puertas fijas y para radiación gamma de $Co^{60}$ a través de puertas fijas o con rotación. Cada factor, multiplicado por la dosis tumor calculada con tablas de dosis a profundidad, ofrece la dosis recibida en la lesión pulmonar o mediastínica.

Se sacan las siguientes conclusiones:

*Para rayos X de 200 kv:* (1) para tumores de cualquier parte del pulmón tratados a través de dos o tres puertas (anterior, posterior, lateral), la dosis tumor calculada será correcta sin que la inexactitud pase de 10 por ciento, sin corrección; (2) para los tumores mediastínicos tratados a través de dos puertas opuestas, no se necesita corrección; (3) para los tumores mediastínicos tratados a través de seis puertas, el factor de corrección es de 1.25.

*Para rayos X de 400 kv:* (1) no se necesita corrección para una lesión pulmonar situada asimétricamente y tratada a través de dos o tres puertas o para una lesión mediastínica tratada a través de dos puertas opuestas, a través del mediastino; (2) para tumores de la porción central de un pulmón tratados a través de dos o tres puertas, el factor de corrección es de 1.15; (3) para una lesión mediastínica tratada a través de seis puertas, el factor de corrección es de 1.20.

*Para radiación gamma de $Co^{60}$.* (1) para lesiones de cualquier parte de la cavidad torácica, excepto el mediastino, el factor de corrección, cuando se usan dos o tres puertas o la terapéutica rotativa, es de 1.15; (2) para las lesiones mediastínicas tratadas a través de tres puertas, el factor de corrección es de 1.20.

# Clinical Experience with Image Intensification[1]

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WITHIN A FEW months of Roentgen's discovery of x-rays, he had made most of the essential observations concerning this new type of energy. Actually, little of fundamental importance concerning the nature of these rays has been added. Great strides have been made, however, in their use. Most of these advancements have been in the nature of engineering triumphs, one of which has been fluoroscopic image intensification.

For years, a few radiologists have looked forward to the time when the efficiency of the fluoroscope, in respect to contrast and detail, would approach that of conventional roentgenography, and "daylight fluoroscopy" would become practical. In 1936, Dessauer suggested that some day fluoroscopy would be possible in bright daylight.

Chamberlain, in 1941, stated concerning image intensification: "In my opinion, it is just around the corner, and, when it comes, it will put medicine and radiology through another revolution not very different from that which followed the advent of roentgenography and present day fluoroscopy at the turn of the century." In 1951, Morgan and Sturm, at Johns Hopkins Hospital, began using an experimental model image intensifier for clinical purposes. In 1953, practical image intensification became commercially available with the introduction of the "Fluorex" image amplifier.[2]

All will agree that greater brightness of the fluoroscopic screen is desirable. The unsatisfactory results of fluoroscopic observation are due to a deficiency of the human eye in observing low levels of brightness. This limitation can be removed only by increasing the brightness of the screen to a level of complete visual acuity. To obtain this end, the brightness of the image must be amplified 500 times, which would mean an increase from the present degree of visual acuity with conventional fluoroscopy, namely 13 per cent, to 100 per cent.

There are two reasons why image intensification is required for this purpose. First, if all the energy of the emerging x-rays were converted into light, this would still not be sufficient to form an adequately bright image. Second, the increase in energy which would be involved in such a procedure would mean also an increase in exposure of the patient. The patient's tolerance thus becomes the limiting factor for obtaining brightness of the fluoroscopic image. The large increase in brightness needed to make up for the shortcomings of conventional equipment and the viewing eye, without a concomitant increase in x-ray intensity, is achieved by intensification of the image as it appears on the screen.

After emerging from the patient, the x-rays strike a fluorescent screen within a highly evacuated glass envelope. Contiguous with the screen is a photoelectric surface, from which photoelectrons are released by the light produced in the screen, in direct proportion to the available light intensity. These free electrons are then accelerated and focused electrostatically onto a smaller fluorescent screen. The accelerated electrons strike this second screen, releasing more light than was released from the input screen by x-rays. In this intensification process, the electrons are concentrated by an electron-optical system which achieves an area reduction 1/25th of the input screen. The increase in brightness of the resultant image is the product of acceleration and concen-

[1] Based upon a paper presented at the Forty-first Annual Meeting of the Radiological Society of North America, Chicago, Ill., Dec. 11–16, 1955.

[2] X-Ray Division, Westinghouse Electric Corporation.

tration. The final fluoroscopic image is then several hundred times brighter than the original image produced by x-rays. An optical system is provided which returns the image to the original size for viewing with both eyes, making possible normal manipulation of the patient and equipment.

While the rather bulky apparatus is considered by some to constitute a drawback, the difficulties from this source may be overcome with practice and are far outweighed by the advantages of intensification. With the power assist and a 180-degree table, there is little excuse for not being able to do anything with the image intensifier that can be done with conventional fluoroscopy, and to do it better. The versatility of this instrument has not been adequately described. It takes time to learn and to appreciate its engineering features.

By taking full advantage of the movement of the optical system and mirror, a comfortable viewing technic can be developed. For example, the mirror is utilized to avoid change in position in performing horizontal fluoroscopy. There is no longer any necessity for leaning over the fluoroscope during this procedure, an advantage which will be appreciated, for example, by anyone who may have occasion to do several barium enema studies in succession. The back may be held straight during the viewing of any portion of the abdomen, and palpation is not hindered in any way with the table in the horizontal position. This is true, whether one is performing a barium enema study, an upper gastrointestinal tract examination, myelography or cardiac catheterization. In vertical fluoroscopy, examination from the pharynx to the symphysis pubis can be performed in a sitting position without flexion or extension of the neck. Some who have used the image intensifier for months have not recognized these possibilities.

Undoubtedly, the chief advantage of the image intensifier is the fact that long periods of dark adaptation are no longer necessary. One may proceed to the fluoroscopic room following consultation before bright illuminators and see through the upper abdomen better than with a conventional fluoroscope after twenty minutes of dark adaptation. This is made possible by the fact that the brightness of the screen has been increased 200 times over that of the conventional screen. Despite the fact that "daylight fluoroscopy" is thus practical, and that one can see reasonably well in the lighted room, we still find it practical to reduce the illumination when using the image intensifier. The light may be varied depending upon the part to be examined or the desire of the fluoroscopist. This is best accomplished through a rheostat which is adjustable at the will of the physician.

Since the dark fluoroscopic room is no longer necessary, the technician can move about without bumping into objects. The referring physician can step in and look through the fluoroscope without losing time adapting his eyes to the dark.

Aside from the factor of accommodation, we find that frequently less time is consumed in fluoroscopy with the image intensifier than in the conventional examination. The increased brightness permits acquisition of the desired information in a relatively short time. In the aggregate, several hours a week are thus saved.

Conventional fluoroscopy is overrated by many radiologists and by most internists. A comparison of the findings with those of an adequate film study is convincing. There is little doubt that the quality of examination will be better with image intensification and that fewer details will be missed. Normal fluoroscopy is carried out at 4 ma, at 80 to 90 kv. With intensification, the chest is satisfactorily visualized at 0.5 ma and 80 kv. This results in a considerable reduction of irradiation of both patient and physician.

One of the chief objections to the image intensifier is the small aperture through which one is forced to work. The only time we have been handicapped in this respect was in visualizing systolic expansion

of the left atrium. The field is too small for visualization of the cardiac apex and the barium-filled esophagus at the same time. This portion of cardiac fluoroscopy is therefore performed without the image intensifier. The small screen size will also be a handicap in cineradiography but in no other phase of fluoroscopy. Seldom is the entire area of the conventional fluoroscopic screen used by the experienced fluoroscopist. For critical work, the x-ray beam is invariably stopped down to include only the object of interest. This improves the contrast by reducing the scattered radiation. Moreover, the eye can examine critically only a limited field at any one time. In this respect image intensification has improved the technic of some fluoroscopists.

The initial cost of the intensifier must be considered another disadvantage. In a department doing a moderate volume of fluoroscopic work, however, the cost of the equipment can be entirely justified by the saving of the radiologist's time and the increased efficiency in use of the fluoroscopic room.

The image intensifier has been used most frequently in examination of the upper gastrointestinal tract, the main reason, of course, being that there is more of this type of work to be done. Demonstration of mucosal detail is far superior to that with the conventional fluoroscope. It cannot be said that the image intensifier has diminished the time required for adequate fluoroscopy of the upper gastrointestinal tract, but neither has it increased this time. After completing the fluoroscopic study with the image intensifier, one feels, at least, that a thorough examination has been made. With the 180-degree table, vertical fluoroscopy can be performed on either side. This obviates the difficulty of reaching under the fluoroscope for palpation. From the opposite side, the right hand can reach around the fluoroscope with the same degree of dexterity that is achieved with the conventional apparatus. As experience in performing vertical fluoroscopy for upper gastrointestinal tract study has accumulated, it seems easier to sit at right angles to the patient rather than in front of him, as for the conventional examination.

One of us (J. E. M.) has outlined a minimum set of films for an adequate gastrointestinal tract study (5). It is not felt that use of the image intensifier has reduced the number of such films required. Polygraphs, which should always be a part of the routine study, can be obtained with little or no loss of time and with a definite saving of films.

There are many who will admit that fluoroscopy of the gastrointestinal tract in obese patients is frustrating and that after a token fluoroscopy dependence must be placed on a good set of x-ray films to ascertain whether or not a pathologic process exists. Admittedly this is not ideal or desirable, and with the image intensifier it is no longer necessary. The clarity of visualization of the gastrointestinal tract in obese patients is truly remarkable.

The fact that it is not necessary to darken the room completely or take time for dark adaptation during the course of the procedure is of particular value in cardiac catheterization. The operator can watch the catheter continuously and is able to discover bleeding promptly. Control of the position of the catheter is far easier with the image intensifier than with the conventional fluoroscope. The catheter tip is readily visible at all times, even when it is moving rapidly as the result of pulsations of the heart. It is not lost to view as it crosses the spine, and it is easily visible even in large hearts and thick-chested individuals. Furthermore, the lighted room does much to alleviate the patient's fear. There is no doubt that this procedure is made much easier by the image intensifier. The fluoroscopic time is cut from ten or fifteen minutes to as little as five minutes. In addition to the advantages obtained in cardiac catheterization, calcification within the heart is more clearly and easily delineated with the image intensifier. This is true of calcific plaques in the coronary arteries as well as valvular

calcifications and calcifications of the annulus fibrosus.

Myelography has been speeded up considerably because of the fact that accommodation is no longer necessary. The person doing the spinal puncture does not have to wear red glasses during this procedure and can see well immediately after placing the opaque contrast material in the vertebral canal. Actually the definition of the column of contrast material is considerably better through the image intensifier, and the vascular pulsations and other details of physiology are more clearly seen.

There are a number of special applications of the image intensifier which may improve the quality of other procedures. We have used it to facilitate removal of foreign bodies and have found it useful in such cases when the surgeon had failed without fluoroscopic control. It has been of aid in setting up laminagraphic studies, although we have not used it for that purpose. It is quite helpful in fluoroscopy during uterosalpingography. The act of swallowing and the action of the vocal cords during phonation are readily observed with the image intensifier. It has been used also to observe intrauterine fetal motions, and in conjunction with venography and bronchography. We utilize the intensifier for many of our therapy localizations. Small metallic clips placed at the time of surgery are easily localized. (Use of the intensifier simplifies and reduces the time necessary for beam localization.)

Image intensification will probably be the medium through which cineradiography will become available to the average physician. This is expected to constitute a major future development in radiology. It is hoped, also, that an intensifier with a larger screen will be forthcoming in the not too distant future. With this improvement, cineradiographic angiocardiography and cerebral angiography will become more practical.


## SUMMARY

A brief review of the development of image intensification is presented, and its usefulness in overcoming some of the shortcomings of conventional fluoroscopy is stressed. It permits a greatly increased brightness of the fluoroscopic image without increased exposure of the patient. The necessity of dark adaptation is eliminated, and the time required for examination is frequently shortened because of the clarity of the details. Disadvantages of the procedure in its present stage of development are the high cost of the equipment and the small field size.

Image intensification has proved most useful in studies of the upper and lower gastrointestinal tract, myelography, and cardiac catheterization. Special applications in connection with other procedures, as foreign body removal, are also mentioned.

Image intensification is the most important step in the development of cineradiography.



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SUMARIO

**La Experiencia Clínica con la Intensificación de las Imágenes**

Ofrécese una breve reseña del desenvolvimiento de la intensificación de las imágenes, recalcando su utilidad para sobrepujar algunas de las deficiencias de la fluoroscopia convencional. Aporta la misma una brillantez mucho mayor de la imagen roentgenoscópica sin aumentar la exposición del enfermo. Se elimina también la necesidad de la adaptación a la oscuridad y frecuentemente se acorta el tiempo requerido para el examen, debido a la claridad de los detalles observados. Las desventajas del procedimiento en su fase actual de desarrollo radican en el elevado costo del instrumental y el pequeño tamaño del campo.

La intensificación de las imágenes ha mostrado su mayor utilidad en los estudios de las porciones superior e inferior del tubo gastrointestinal, la mielografía y el cateterismo cardíaco. También se mencionan sus aplicaciones especiales en relación con otros procedimientos, tales como la extracción de cuerpos extraños y la localizacion del haz en la terapeutica.

La aplicación a la cinerradiografía es un posible desenvolvimiento del futuro.

# Lymphangioma of the Colon: Roentgen Aspects

## A Case Report[1]

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Because of the rarity of lymphangioma of the colon and the absence from the literature of any account of its distinctive radiologic aspects, the following case is reported.

### CASE REPORT

G. W., a 32-year-old white female, was admitted on March 10, 1955, complaining of vague recurring right lower abdominal pain and intermittent constipation since 1948. In 1949 she underwent an appendectomy, without relief of symptoms. She subsequently consulted many physicians and received a wide variety of symptomatic treatment. In late 1954, her abdominal distress recurred and a barium enema study was performed. It revealed a filling defect in the lateral wall of the ascending colon, suggesting a neoplasm. The patient was then referred to Valley Forge Army Hospital for further study and definitive therapy.

Physical examination revealed only tenderness upon deep palpation in the right lower quadrant of the abdomen. No masses were palpable and no muscle spasm was elicited. Studies other than roentgen evaluation were non-contributory. These included examination of the stools for blood, ova, and parasites.

Roentgen examination of the chest and the upper gastrointestinal tract revealed no abnormality. A barium enema study on March 15, 1955, demonstrated a radiolucent defect on the posterolateral aspect of the ascending colon, 11 cm. distal to the tip of the cecum, measuring 2.5 × 3.0 cm. in diameter. The lesion was oval, lobulated, and had well defined margins (Fig. 1). The colon in the area of involvement was mobile, and the shape and size of the lesion changed greatly on palpation. It was best visualized with incomplete filling of the ascending colon and cecum (Fig. 2). With increasing barium distention, the defect disappeared from view and could not be revisualized even after evacuation. The mucosa was intact.

On March 18, re-examination by means of barium enema again disclosed the filling defect, indicating its intramural location without mucosal involvement. During fluoroscopy, its contour was variable (Fig. 3). On March 25, an air-contrast study was performed; the lesion was not demonstrable during air distention. Examination in the decubitus position with the horizontal beam, showed the lateral contour of the ascending colon to be normal (Fig. 4). These observations indicated the presence of a benign intramural tumor of the ascending colon. Its characteristics were believed to be those of a lipoma.

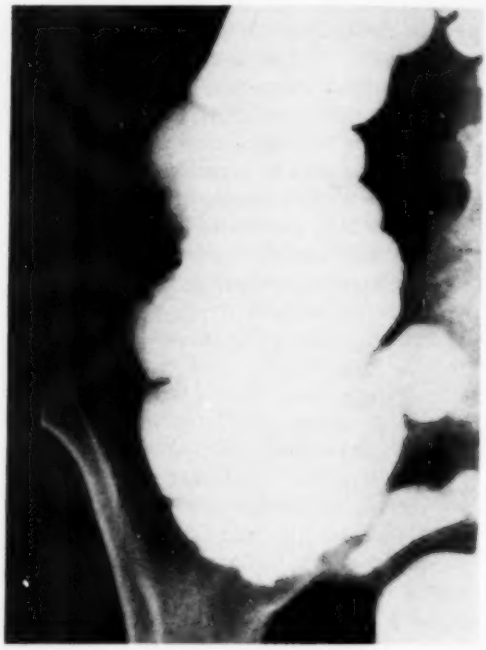

Fig. 1. Barium enema study in filled phase, showing a poorly defined defect along the lateral wall of the ascending colon.

Exploratory laparotomy was performed on April 4. Several adhesions binding the colon to the right lateral parietal peritoneum were released. Ten centimeters from the cecal tip a cystic lesion was found. The muscularis was compressed and displaced; the mucosa was intact. The cyst was excised by means of a colotomy. The postoperative course was uneventful and the patient was discharged on April 13, free of abdominal complaints. The pathological report (Capt. Theodore E. Ludden) was "lymphangioma of the ascending colon."

### DISCUSSION

With the exception of the adenomatous

[1] From the Valley Forge Army Hospital, Radiological Service, Phoenixville, Penna. Accepted for publication in February 1956.

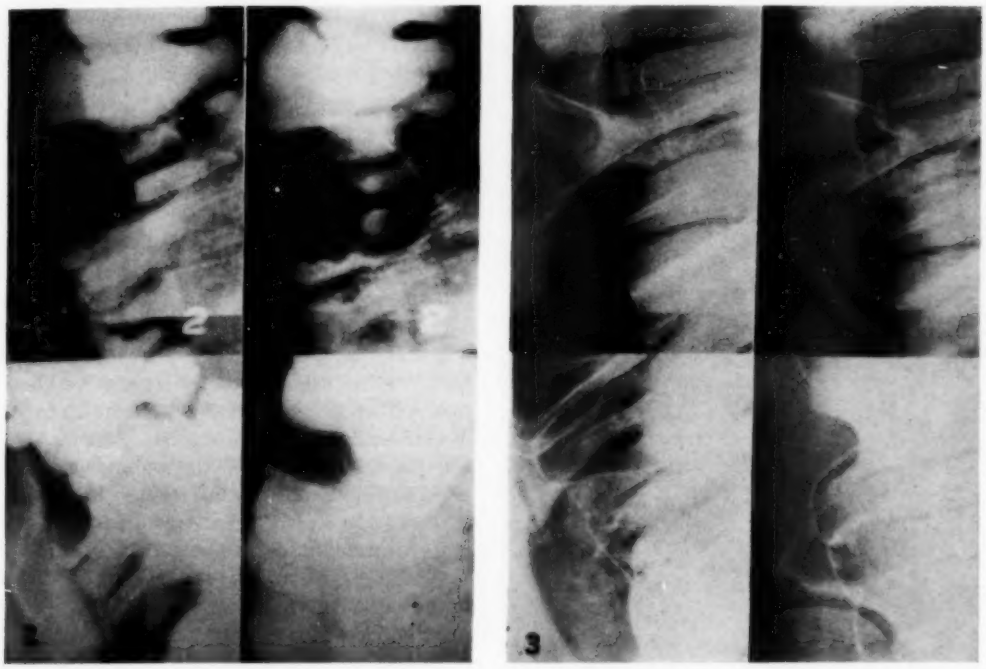

Fig. 2. Series of fluorographic films made as the ascending colon filled with barium. Initially there is a marked radiolucency produced by the rounded lesion projecting into the lumen. The mass loses its distinct contour as increasing barium distention displaces it laterally.

Fig. 3. Barium-air contrast fluorographic films showing the sharp smooth edges. The two lower studies were made with the application of compression; the lesion is not demonstrated.

polypoid tumors, benign neoplasms of the colon are extremely rare. Raiford reported only 87 benign tumors in a review of 11,500 autopsies and 45,000 surgical specimens from Johns Hopkins Hospital (11). Helwig found 154 benign tumors in

Fig. 4. Barium-air contrast examination in decubitus position, right side up. No filling defect shown.

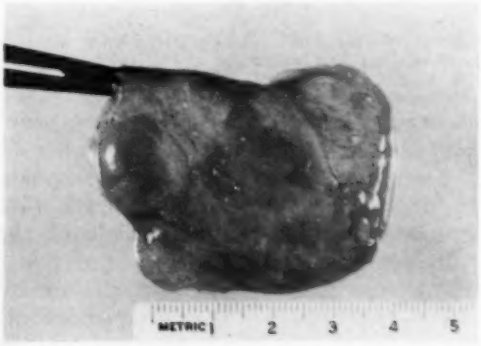


Fig. 5. Specimen as removed at surgery, before opening, demonstrating the multicystic, thin-walled character and translucency of the tumor.

1,460 consecutive autopsy examinations of the entire large intestine (5). Ehrlich and Hunter, in a study of the material from the Armed Forces Institute of Pathology for the period of the Second World

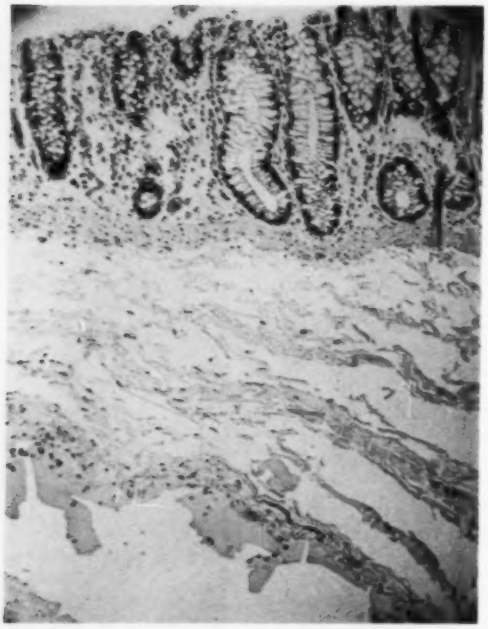

Fig. 6.—Microscopic section (×70) demonstrating normal mucosa, submucosal collagenous tissue, and strands of smooth muscle. A cystic space lined by endothelium and containing lymphocytes is seen in the lower portion.

War, found 263 benign tumors but no lymphangiomas (4).

Nine cases of lymphangioma of the gastrointestinal tract have appeared in the English literature (1–3, 8–11, 14, 15). Six arose in the jejunum or ileum and 3 in the rectum. None is reported to have exhibited identifiable roentgen manifestations.

Lymphangiomas are thought to originate in the lymphatic plexus within the submucosa, into which the lacteals of the villi empty. Three theories of development have been advanced: that they are due to hyperplasia of misplaced embryonic tissue; that they result from hyperplasia of normally placed lymphoid tissue in the submucosa (12); that the mesenteric lymph nodes are obstructed, with subsequent stasis and dilatation due to a rise in pressure within the nodes (10). The last supposition seems the most plausible. It is consistent with the cystic character of the tumor.

Benign tumors of the colon, exclusive of polyps, are usually asymptomatic for years. Only after enlarging sufficiently to produce a noticeable mass, partial obstruction, or intussusception, are they brought to the attention of a physician. Gross bleeding is uncommon except in the case of hemangiomas. In lymphangioma the symptoms are poorly defined, ranging from none at all to vague abdominal distress with episodic constipation. Clinically, a secondary anemia of a moderate to severe degree has been a constant finding when the lesion occurs in the small intestine. Evidence of hemorrhagic extravasation within the tumor was present on gross examination in 2 such cases. Anemia has not been a feature of the colonic lymphangiomas. Constipation of moderate degree is a usual complaint and is probably due to mechanical interference with the motility of the colonic wall. This has been noted in association with other benign intramural tumors (13).

Grossly, lymphangiomas are grayish, yellow, or yellow-pink in color. They are very soft, fluid-filled cystic masses with extremely thin walls. The contents may be clear, yellow-tinged, or hemorrhagic. By squeezing, some of the fluid can be expressed through the translucent walls. The larger tumors may produce bulging of the serous as well as the mucosal surfaces (Fig. 5).

Microscopically the cystic spaces are found to be lined by endothelium which is situated in close proximity to collagenous elastic tissue and smooth muscle. These elements are arranged in patterns characteristic of vessel walls. Numerous lymphocytes are embedded in the spaces (Fig. 6).

## ROENTGEN ASPECTS

Although lymphangioma of the gastrointestinal tract has yet to be diagnosed prior to surgical exploration, distinctive radiographic characteristics are found. The tumor is demonstrated as a sharply marginated, peripheral, oval to round colonic defect, indicating an intramural location. It is associated with an intact mucosa.

Due to its variable contour and cystic nature, with the fluid readily passing between its thin internal septa, roentgen demonstration of the tumor is evanescent. It is best visualized during partial barium filling of the colon and disappears with colonic distention by barium. Similarly, application of compression, and distention of the colon with air cause disappearance of the lesion. Evacuation studies are usually non-contributory, because of the intact mucosa and the pliability of the tumor.

Cavernous hemangiomata and lipomata are other benign tumors which may exhibit similar roentgen characteristics. Differentiation depends on demonstration of calcification within the hemangioma, together with alteration of the colonic wall (6). Lipoma can be distinguished only if a dense capsule and numerous traversing linear strands are visible (2). Demonstration of a pedicle excludes lymphangioma, since in none of the reported cases was the tumor pedunculated.

## SUMMARY

A case of lymphangioma of the ascending colon is presented, the tenth reported instance of this tumor in the gastrointestinal tract.

The distinctive roentgen characteristics are described for the first time. The tumor is demonstrable on partial barium filling of the colon as a fluctuant, intramural mass, without muscosal changes.

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## SUMARIO

### Linfangioma del Colon: Aspectos Roentgenológicos. Presentación de Un Caso

Preséntase un caso de linfangioma del colon. Trátase de un tumor extraño, cuyos aspectos roentgenológicos han recibido poca atención. Es observable en forma de nicho periférico marginado agudamente, redondo u oval, indicando localización intramural. La mucosa se halla intacta. Debido al contorno variable y naturaleza quística del tumor, la observación radiológica es evanescente. Se visualiza mejor durante el henchimiento parcial del colon, tendiendo a desaparecer con la distensión del intestino ya por bario o aire.

El linfangioma del colon tiene que ser diferenciado del hemangioma cavernoso y del lipoma.

# EDITORIAL

## Tumors of the Heart

Few reports on the diagnosis of tumors of the heart are to be found in the current radiologic literature. The much larger number of cases appearing in the clinical and pathological journals would seem to indicate that greater attention should be paid to the roentgenographic and allied aspects of these neoplasms. With the development of angiography for the study of organic defects of the heart, we have a method which should lead to the more frequent demonstration of cardiac tumors.

Primary tumors of the heart are of rare occurrence. Figures from different diagnostic centers vary. According to Straus and Merliss, however, 8 cases appeared in the American literature between 1938 and 1952. Assuming that all cases coming to autopsy in that period were reported, and accepting the figure of the American Medical Association for the number of autopsies performed during the same years, namely 480,331, the incidence of primary heart tumors becomes 0.0017 per cent (1). The site of these tumors in the heart is not constant, but the larger number are located in the atria. A mesoblastic origin is usual, and most of the reported cases have been classified as myxoma, sarcoma, angioma, rhabdomyoma, fibroma, and hamartoma. Considerable controversy has arisen regarding these tumors, especially the myxoma, the neoplastic nature of which has not always been accepted.

Secondary heart tumors are of relatively more frequent occurrence. A typical figure for a general hospital series has been given as 0.6 per cent, while in autopsies limited to patients with malignant disease the range is from 2.0 to 13.9 per cent (2). In one series of 8,414 autopsies on cancer patients, metastases were present in the myocardium in 3.9 per cent (3). In only 1 of this number was the cardiac deposit the sole metastasis to be found. The origin of these metastases varies widely, but cancers of the breast, melanomas, lung tumors, and lymphomas head the list. It is generally stated that the right side of the heart is more frequently involved than the left, although some observers have found the distribution between the two sides to be equal. In Prichard's series (3) metastases occurred by three routes, embolic, lymphatic, and direct invasion, in the order listed.

The clinical picture which leads one to suspect a tumor of the heart is by no means clear-cut. In patients with known cancer elsewhere, the development of cardiac failure with no other apparent basis is highly suggestive of cardiac metastasis. Disturbance of cardiac rhythm, pericardial effusion of the hemorrhagic type, signs of obstruction of the superior vena cava, tachycardia, evidence of constrictive pericarditis, and especially roentgen delineation of an unusual heart border and fluoroscopic demonstration of relative immobility of the right heart, should put one on guard if these findings cannot be reasonably explained by other causes.

A review of reported cases reveals the important role that the radiologist plays in the diagnosis of tumors of the heart. In some instances the cardiac contour presents a deformity which is suggestive of a neoplasm. Usually, however, special technics are required to confirm the diagnosis. Sometimes calcification in the tumor will afford conclusive evidence of its location and size (4, 5). The importance of the fluoroscopic demonstration of relative immobility of the right heart has already

been mentioned. The development of pericardial effusion, which proves to be hemopericardium, is an important clue, although this may also be found in tuberculous pericarditis. In some cases, pneumopericardium has been used effectively to outline the tumor and clarify the diagnosis (6).

The reports of tumors of the heart diagnosed and localized by means of angiocardiography indicate a forward step toward the solution of this problem. Cheng and Sutton (7) report a case of hemangioendotheliosarcoma in the right atrium diagnosed antemortem. Bahnson and Newman (8) demonstrated a myxoma, also in the right atrium. It produced a dilated superior vena cava and a large filling defect. The tumor was subsequently removed surgically. Three cases of myxoma of the left atrium were demonstrated angiographically by Steinberg, Dotter, and Glenn (9). They found a constant filling defect in an enlarged atrium, with attachment to the interatrial wall.

As indicated above, primary tumors of the heart are infrequently found at autopsy. Much less frequently are they diagnosed antemortem. Secondary tumors of the heart are much more common, especially in series emanating from cancer centers, where lists are heavily loaded with primary malignant disease. The radiologist can do much to increase the percentage of antemortem diagnoses by familiarizing himself with the various radiologic procedures which are of proved value in such cases. The advent of angiocardiography has produced a powerful adjunct for demonstrating and locating accurately certain of these tumors. It is not too much to expect that with earlier diagnosis and the perfection of cardiac surgery some of these tumors may be successfully removed in the near future.

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### LOS ANGELES RADIOLOGICAL SOCIETY ANNUAL MID-WINTER CONFERENCE

The Ninth Annual Mid-Winter Radiological Conference, sponsored by the Los Angeles Radiological Society, will be held at the Biltmore Hotel, Los Angeles, Saturday and Sunday, Feb. 23 and 24, 1957. Guest speakers will include: Dr. John Caffey, New York; Dr. Johan Frimann-Dahl, of Ulleval Hospital, Oslo, Norway; Dr. Merrill C. Sosman, Boston; Professor Brian W. Windeyer, University of London and Middlesex Hospital, London, England.

The conference fee of $20.00 includes two luncheon meetings, each featuring a question and answer period. A banquet ($7.50 per plate), preceded by cocktails, will be held Saturday evening. Reservations may be made through Dr. Louis J. Bonann, 1245 Glendon Ave., Los Angeles 24, Calif.

Courtesy cards will be available to residents in radiology and radiologists in the Armed Forces by advanced registration, with reduced fees for the luncheons and banquet. Hotel reservations should be made promptly through the Convention Manager, Biltmore Hotel, Los Angeles, Calif.

### OREGON RADIOLOGICAL SOCIETY

At the annual meeting of the Oregon Radiological Society, Dr. James Haworth, of Salem, was installed as President, and the following officers were elected for 1956–1957: President-Elect, Dr. J. Wayne Loomis, Portland; Vice-President, Dr. G. Kenneth Vollmar, Salem; Secretary-Treasurer, Dr. Norman L. Bline, 806 S. W. Broadway, Portland 5, Ore.; Executive Committeeman (1956–1959), Dr. Milton D. Hyman, Portland; Councilor to the American College of Radiology, Dr. Charles T. Dotter, Portland; Alternate Councilor, Dr. J. Richard Raines, Portland.

### SOCIEDAD CHILENA DE RADIOLOGIA

The present officers of the Sociedad Chilena de Radiología are Dr. Julio Hasbun, President, and Dr. Armando Doberty, Merced 565, Santiago de Chile, General Secretary. The society meets on the fourth Friday of each month.

### UNIVERSITY OF TEXAS COURSE IN RADIOLOGICAL PHYSICS AND MEDICAL USE OF RADIOISOTOPES

Announcement is made by the University of Texas Postgraduate School of Medicine of a practical course in Radiological Physics and Medical Use of Radioisotopes, to be given at the M. D. Anderson Hospital and Tumor Institute, Houston. Applicants may register for Part I and/or Part II; enrollment is limited.

Part I (two months, beginning in January 1957 and July 1957) will cover the practical applications of radiologic physics and Part II (one month, to begin in March 1957 and September 1957) will be devoted to the medical use of radioisotopes.

Additional information and application blanks may be obtained from the University of Texas Postgraduate School of Medicine, Texas Medical Center, Houston 25, Texas.

### OAK RIDGE INSTITUTE OF NUCLEAR STUDIES

Announcement was recently made, at a banquet celebrating the tenth anniversary of the Oak Ridge Institute of Nuclear Studies, of the acquisition of a 38-acre plot, to become the site for the permanent headquarters of the Institute. Tentative proposals for the contemplated development provide for approximately 168,000 square feet of floor space, including a general administration building, a technical library, a dormitory and dining hall, quarters for the Institute's Medical Division with a thirty-four-bed hospital, a Museum of Atomic Science, and technical shops.

Construction of these facilities is contingent on securing the necessary funds through grants or gifts from foundations and other non-government sources and will extend over a period of several years.

### GOLD MEDAL OF THE SEVENTH ARGENTINIAN CONGRESS OF RADIOLOGY

At the Seventh Argentinian Congress of Radiology, held in Rosario, Sept. 27–29, 1956, the Gold Medal "Mentor de la Radiología Americana" was conferred upon Dr. Luis Arrieta Sanchez of Panama. The award was made in recognition of his contributions to radiology, his editorship of *Radiología*, the official organ of the Sociedad Radiologica Panameña, and his initiative in introducing new radiologic technics and modern methods into his country.

## Books Received

Books received are acknowledged under this heading, and such notice may be regarded as recognition of the courtesy of the sender. Reviews will be published in the interest of our readers and as space permits.

CLINICAL ROENTGENOLOGY. VOLUME IV. THE DIGESTIVE TRACT, THE GALL BLADDER, LIVER AND PANCREAS, THE EXCRETORY TRACT AND

SPECIAL STUDIES EMPHASIZING DIFFERENTIAL CONSIDERATIONS. By ALFRED A. DE LORIMIER, M.D., Radiologist, Saint Francis Memorial Hospital, San Francisco, California, Consultant in Radiology for the United States Army, at the Letterman Army Hospital, Consultant in Radiation Therapy for the United States Public Health Service at the U. S. Marine Hospital, San Francisco, Former Commandant. The Army School of Roentgenology; HENRY G. MOEHRING, M.D., Radiologist, Duluth Clinic, Duluth, Minnesota, Former Director, The Army School of Roentgenology; JOHN R. HANNAN, M.D., Radiologist, Cleveland, Ohio, and Lake County Memorial Hospital, Painesville, Ohio, Former Director, The Army School of Roentgenology, Associate Professor of Diagnostic Roentgenology, the Frank E Bunts Educational Institute, Cleveland Clinic Foundation, Department of Roentgenology, Cleveland Clinic Foundation. A volume of 700 pages, with 1,112 illustrations. Published by Charles C Thomas, Springfield, Ill., 1956. Price $24.50.

TUBERCULOSIS CONTROL: PLANS FOR INTENSIFIED INTER-COUNTRY ACTION IN EUROPE. REPORT OF A STUDY-GROUP. World Health Organization Technical Report Series No. 112. A pamphlet of 14 pages. Published by the World Health Organization, Palais des Nations, Geneva, September 1956. Price $.30.

ATTUALE ORIENTAMENTO NELLA RADIODIAGNOSTICA DELLE MALATTIE TORACICHE. (POSSIBILITÀ E LIMITI DELLA COMUNE TECNICA RADIOLOGICA). By Dott. RENATA BEVILACQUA, Aiuto e Vice Direttore Incaricato, Consorzio Provinciale Antitubercolare di Milano, Dispensario Centrale (Direttore, Prof. Mario Bello). A volume of 184 pages, with 175 figures. Published by Edizioni Minerva Medica, Torino, Italy, 1956. Price L. 3000.

## Book Reviews

THE LUNG AS A MIRROR OF SYSTEMIC DISEASE. By ELI H. RUBIN, M.D., Professor of Clinical Medicine, Albert Einstein College of Medicine, Yeshiva University; Director of Pulmonary Diseases, Bronx Municipal Hospital Center; Attending Physician, Division of Pulmonary Diseases, Montefiore Hospital; Consulting Physician in Pulmonary Diseases, Lebanon and Morrisania City Hospitals, New York, N. Y. A volume of 288 pages, with 92 figures and 11 tables. Published by Charles C Thomas, Springfield, Ill., 1956. Price $12.50.

Evidence of disseminated disease may frequently be discovered on examination of the chest, and the alert observer may profit by an awareness of this situation. In this work on *The Lung as a Mirror of Systemic Disease*, the author emphasizes the importance of the chest film in the detection of a wide variety of conditions, without, however, neglecting the value of a complete history, physical examination, laboratory tests, and finally biopsy, which may be required for the final diagnosis.

Included are sections describing the pulmonary changes to be observed in various disorders of metabolism, blood diseases, the allergies, diseases of the skin and mucous membranes, certain abdominal and metastatic diseases, and cardiovascular conditions. Ample attention is given to the symptomatology and physical signs of the diseases considered and their relationship to the findings on the chest film. A final chapter is devoted to laboratory and exploratory procedures.

The volume is attractively printed, with numerous reproductions of roentgenograms, photographs, and photomicrographs. Each chapter has its own bibliography. Chest physicians will find this book of special interest and it has much to offer to the radiologist.

## In Memoriam

JOHN J. McGUIRE, M.D.

1895–1956

Dr. John Jett McGuire, of Pensacola, Fla., died suddenly on July 1, 1956, of a coronary occlusion. Dr. McGuire was born on Feb. 4, 1895, at DeFuniak Springs, Fla., and was educated in the public schools of Walton County, Fla., and at the Virginia Military Institute. He received his M.D. degree from Tulane University in 1919 and practiced radiology both in DeFuniak Springs and Albuquerque, N. M., before settling in Pensacola in 1931.

Dr. McGuire was a member of the Radiological Society of North America, a Diplomate of the American Board of Radiology, a Fellow of the American College of Radiology, and a member of the Florida Radiological Society, having served the latter both as President and Secretary. He belonged also to the Escambia County Medical Society, the Florida Medical Association, and the American Medical Association. He was a member of the Methodist Church.

Modesty, sincerity, intense love of and devotion to family, and loyalty to friends were Dr. McGuire's outstanding characteristics. He commanded the respect and high esteem not only of his colleagues in the medical profession but of all with whom he dealt. Throughout his life, he served his community untiringly and well. For these labors, and for his integrity in his profession and private life, he will long be remembered.

BARCLAY D. RHEA, M.D.
JOHN J. BAEHR, JR., M.D.

# ABSTRACTS OF CURRENT LITERATURE

## ROENTGEN DIAGNOSIS

### The Head and Neck



### The Chest



### The Cardiovascular System



### Hernia



### The Digestive System

## RADIOTHERAPY

## RADIOISOTOPES



## RADIATION EFFECTS

## THE HEAD AND NECK

**Measuring the Pituitary Fossa from Radiographs.** Roy M. Acheson. Brit. J. Radiol. **29**: 76–80, February 1956. (Radcliffe Infirmary, Oxford, England)

The author has previously described his technic for obtaining dimensions of the pituitary fossa from lateral films (Brit. J. Radiol. **27**: 298, 1954). The length is measured from the tuberculum sellae to the dorsum sellae, and the depth from the line joining these points to the lowest part of the sella. Possible sources of error in the measurements thus obtained are use of different x-ray tubes, variation in the distance between the tube and film, tilt or rotation of the head, and difficulty in recognizing the fixed points.

To determine the error in measuring the adult fossa, a comparison was made of two separate examinations on each of 4 subjects. The radiographs for each individual were reproduced on photographic film. Variation between the two radiographs indicated the error due to change of position of the head, while variations between the radiographs and photographic reproductions indicted the error in identification of the points on which the measurements were based. According to these observations, increases in length of 1.8 mm. and in depth of 0.6 mm. are to be regarded as significant.

The pituitary fossae of 129 adults presumed to be free of intracranial disease were then measured, and a normal distribution curve was constructed, showing a length of 10.2 to 16.6 mm. Of interest was the fact that 81 per cent of the fossae were between 10.2 and 14.8 mm., thus allowing for significant lengthening (1.8 mm.) without exceeding the normal range. Owing to this very wide normal distribution, measurement of a single film may often fail to reveal minor degrees of enlargement unless accompanied by erosion. It is concluded that such pathological enlargement is best detected by measuring serial films, provided these are taken while the enlargement is occurring. This applies to both adults and children.

Determinations were also made of the mean length and depth of the pituitary fossa during the first five years of life in a group of children, together with the mean annual increase.

Measurement of the pituitary fossa had previously been undertaken in an attempt to assess pituitary function in children, and in studies of growth. It was convincingly shown that the size of the pituitary gland bears no relation to the fossa, with striking differences in the growth curves of these two structures. Also the gland can undergo considerable enlargement without interfering with the morphology of the fossa. That the size of the sphenoid sinus acts as a radiological indication of pituitary function in children has, however, been recently suggested.

Four roentgenograms; 2 graphs; 1 diagram; 5 tables.

C. M. Greenwald, M.D.
Cleveland Clinic

**Some Experiences with Tomography in Neuroradiology.** Vincenzo Valentino. Acta radiol. **45**: 101–105, February 1956. (Institute of "Semeiotical Medica," Naples University, Naples, Italy)

By means of 2 illustrative cases, the author indicates the value of tomography in demonstrating bone structure at the base of the skull in better detail than is obtainable with routine films. In 1 case tomograms revealed bone destruction in the middle fossa due to an intracranial neoplasm, ruling out the possibility of extension from a nasopharyngeal tumor. In the other they disclosed an anatomic anomaly in the form of an area of increased bone density symmetrically situated in the two pterional areas, excluding a pterional meningioma.

The author uses lateral tomograms, also, to supplement encephalography when the posterior portion of the ventricular system is not well demonstrated.

Eight roentgenograms; 1 photograph.

Damon D. Blake, M.D.
Bowman Gray School of Medicine

**Stratigraphy of the Sella Turcica.** Eva Šilinková-Málková and Oskar Blažek. Československ. Roentgenol. **9**: 105–111, 1955. (In Czech)

Conventional views of the sella turcica, even spot-films, can seldom provide sufficient information. Considerable detail may be obtained with body-section roentgenography, as determined by the authors in a four-year experience with this method. A Siemens planigraph (150 cm. focal distance) was used, with the patient standing for the frontal (nose-forehead) projection and sitting for the lateral view. The head is maintained in the proper position by a band. Eight views on two 18 × 24-cm. roentgenograms are obtained in each projection. The sections are placed at intervals of 0.5 cm., starting in the frontal projection 6.5 cm. posterior to the glabella and continuing to 10 cm. In the lateral projection, the first layer should be 2 cm. from the mid-line, continuing to 2 cm. beyond the mid-line on the opposite side. Fluoroscopic control facilitates centering, so that small size spot-views are possible.

With this method, it is claimed, very small lesions of the sella may be recognized. It should be of special value in demonstrating asymmetric lesions, excavations of the fossa, and destruction of the clivus.

One photograph; 12 roentgenograms.

Victor J. Fish, M.D.
Cook County Hospital, Chicago

**Experiences with Hypaque. A New Contrast Media in Cerebral Angiography.** Edmund A. Smolik and Francis P. Nash. Missouri Med. **53**: 99–101, February 1956. (3720 Washington Blvd., St. Louis 8, Mo.)

Thirty-nine cerebral arteriograms were obtained in 30 patients with 50 per cent Hypaque, under light sodium pentothal anesthesia. The patients ranged in age from sixteen to thirty-five years. The series included 5 vertebral arteriograms, 4 bilateral carotid injections, and 30 percutaneous injections. The average volume of the medium administered to each patient was 44 c.c.

The sharp, distinct vascular outline achieved with Hypaque was in every case considered superior to that obtained with other media. In 3 instances, the Hypaque solution was serially diluted to determine the lowest concentration affording adequate visualization. Concentrations of less than 40 per cent failed to give as good a result as that obtained with the 50 per cent solution.

In no instance did a significant change in body temperature, blood pressure, pulse, or respiratory pattern follow the injections, nor were there abnormal soft-tissue reactions at the injection site. In 6 cases, a transient, slight facial pallor or flush was noted.

Eight roentgenograms; 1 diagram.

**Skeletal Changes in the Skull in Cavernous Vascular Tumors.** M. Pöschl. Fortschr. a. d. Geb. d. Röntgenstrahlen **84**: 209–213, February 1956. (In German) (Nussbaumstrasse 20, Munich 15, Germany)

The skull is rather frequently the site of vascular tumors, the cavernous form predominating over the capillary type. Externally the tumor may change in size, sometimes without apparent cause; it tends to become smaller with continuous digital pressure, while forward flexion of the head will cause it to appear larger.

Roentgenologically, the cavernous vascular tumors produce lacunar and canalicular bone changes. In addition, the following findings have proved to be of diagnostic value: (1) In the cranial vault the emissary veins and adjacent diploic channels are frequently dilated, occasionally penetrating through the external table. (2) Gyrate or irregularly shaped areas of pressure atrophy may develop, simulating digital markings without actually corresponding to the shape or form of the convolutions. (3) In adolescence there may be associated skeletal changes and retardation of bony growth. (4) Vascular concrements are of help in confirming the diagnosis.

Four cases are reported in which ovoid deformities of the ipsilateral orbit were observed in addition to changes at the cranial base.

In the differential diagnosis the following conditions are to be considered: atheroma, eosinophilic granuloma, dermoid cyst, meningocele, erythroblastoma, and gumma.

Seven roentgenograms. ERNEST KRAFT, M.D.
Newington, Conn.

**An Unusual Case of Sphenoid Abscess.** Claude E. Cody, III. Arch. Otolaryng. **63**: 199–202, February 1956. (1304 Walker Ave., Houston 2, Texas)

The author reports an unusual case of sphenoid abscess in which direct examination of the nose was largely normal. Roentgen examination disclosed a large, thick-walled right sphenoid sinus filled with a dense opaque material. At operation, by way of the right ethmoid region, a large sinus cavity was found, filled with pus, debris, and thick cheesy material; the entire anterior wall of the structure was removed as high as the level of the dura and as low as possible.

The patient had been under treatment elsewhere for two and a half years, during which she had undergone 3 craniotomies and acquired a drug addiction in attempts to alleviate severe pain. The author uses this case to stress the importance of adequate x-ray views and interpretation. The views he found to be most helpful were the routine lateral view of the skull and the Hirtz or mentovertex position.

Three roentgenograms; 2 photomicrographs; 2 drawings.

**Lateral Pharyngeal Diverticula.** S. A. Kaufman. Am. J. Roentgenol. **75**: 238–241, February 1956. (Massachusetts Memorial Hospital, 750 Harrison Ave., Boston 18, Mass.)

The author reports a case of lateral pharyngeal diverticulum and presents a brief review of the literature. Lateral pharyngeal diverticula are rare but should be considered in the differential diagnosis of dysphagia, especially when the symptoms are of long duration and the cause obscure. They may be either acquired or congenital.

The patient was a 75-year-old white male with a history of dysphagia for many years. A barium study of the pharynx and esophagus revealed a 4-cm. diverticulum arising from, and connected with, the right vallecula by a narrow aperture. Endoscopic examination revealed a slit-like orifice in the vallecula.

Lateral pharyngeal diverticula are of three types: (1) those occurring as a result of prolonged excessive pressure on anatomic weak areas, such as occur in glass blowers; (2) the artificial pouches created manually by prisoners in India as a hiding place for coins; (3) congenital diverticula as in the case reported here. The latter are thought to be remnants of the third or fourth branchial clefts, which are normally obliterated in the course of embryonic development. They vary from mere dimpling of the skin to a complete tract.

Three roentgenograms; 1 drawing; 1 table.

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## THE CHEST

**Isolated Primary Mesenchymatous Tumors of the Lungs and Bronchi.** P. Galy and R. G. Touraine. J. franç. de méd. et chir. thorac. **10**: 168–193, 1956. (In French) (Laboratoire de la Clinique Chirurgicale, Lyon, France)

In eight years (1948–1955) over 300 "bronchopulmonary epitheliomas" and almost 50 bronchial adenomas have been treated at the Surgical Clinic of the University of Lyon. In the same interval, 12 primary mesenchymatous tumors of the lungs and bronchi were excised. These latter cases may be briefly summarized as follows.

(1) Male, 27, right lower lobectomy in 1952, no recurrence when last seen in 1953. Endobronchial leiomyofibroma, cytologically benign but having invaded an adjacent lymph node.

(2) Female, 52, partial left lower lobectomy. Benign hamartochondroma.

(3) Male, 15, left pneumonectomy in 1949, no recurrence when last seen in 1954. Pulmonary fibroma with questionable malignant features (fibrosarcoma?).

(4) Female, 10, enucleation of round lesion from superior segment of left lower lobe. Fibromyxomatous schwannoma.

(5) Male, 11, right pneumonectomy in 1948, postoperative irradiation, died in 1949. Fusocellular sarcoma.

(6) Male, 32, roentgen evidence of growing tumor since 1949, right upper and middle lobectomy in 1952, died same year. Fibrosarcoma with considerable collagenous component.

(7) Male, 67, hemoptyses since 1948, left pneumonectomy in 1950, alive and well in 1954. Fusocellular sarcoma.

(8) Male, 48, right lower lobectomy in 1954. Histiocytic sarcoma.

(9) Male, 48, right pneumonectomy in 1955. Fibroleiomyosarcoma.

(10) Female, 63, right pneumonectomy in 1955, postoperative irradiation. Histiocytic sarcoma.

(11) Male, 30, enucleation of mass from mediastinal aspect of left lower lobe in 1955, postoperative irradiation. Histiocytic liposarcoma.

(12) Female, 50, hysterectomy for uterine fibroma in 1944, right pneumonectomy in 1948, died in 1949. No histologic evidence of metastatic features. Malignant schwannoma.

In the bronchus, mesenchymatous tumors cause partial or total obstruction, the bronchoscopic appearance being that of a polypoid mass, yet non-invasive. These tumors are most often benign, even when histologically there are malignant features.

In the lung, mesenchymatous tumors are usually asymptomatic and are often an unexpected finding on a routine chest roentgenogram, appearing as a rounded, opaque, mass of homogeneous density. By contrast with the bronchial localizations, the pulmonary tumors are almost always malignant, even in the presence of histologically benign characteristics, but they extend slowly and metastasize late and infrequently. Surgical resection and postoperative irradiation will result in a longer average survival time than in bronchogenic carcinoma.

In mesenchymatous neoplasms it is difficult to establish the cellular component, and the findings are often subject to individual interpretation. It is more important to determine the degree of malignancy, which in itself is not always an easy task for the pathologist.

Four roentgenograms; 6 photographs; 6 photomicrographs.

I. F. HUMMON, M.D.
Cook County Hospital, Chicago

**Metastatic Lung Tumors. Study of 152 Cases.** Armando Paglicci. Radiol. med. (Milan) **42**: 184–192, February 1956. (In Italian) (Istituto di Radiologia Medica della Università di Roma, Rome, Italy)

At the Medical Radiological Institute of the University of Rome, betwen 1944 and 1954, 152 patients (78 males, 74 females), ranging in age from six and a half to eighty-one years, were found to have metastatic lung tumors. Roentgenologically, these were of four types: (1) the *nodular* type, well circumscribed, mostly homogeneous, rounded or oval densities of various sizes, from "miliary" lesions to those measuring 6 or 7 cm. in diameter; (2) the *reticular* type, with localized or diffuse lymphangitic spread; (3) the *infiltrative* type, with ill-defined, patchy opacities, confluent in places; (4) the *mixed* type. As a rule, the diagnosis was easily made, but occasionally biopsy was required. Diligent search usually uncovers the primary lesion, but it may remain obscure, as in 4 cases in this series.

The primary site of the disease in 37 patients (all females) was the breast; in 29 (23 males) the urogenital system; in 28 (18 females) the bones; in 11 (6 males) the soft tissues; in 8 (5 males) the digestive system; in 6 (4 males) the thyroid; in 3 the nervous system; in 2 the tongue. Five of the metastatic deposits (4 in males) originated from lymphoblastoma, and in 1 each from a craniopharyngioma, an orbital tumor, and a tumor of the temporal fossa. Up to ten years of age, Ewing's sarcoma predominated; in the second and third decades the primary lesion was more often in the bones, testicle, or soft tissues (fibrosarcoma). Only 10 per cent of metastatic breast tumors were seen before the fifth decade.

Three tables.

E. R. N. GRIGG, M.D.
Cook County Hospital, Chicago

**The Chromate Carcinoma of the Lung and Benign Tumors in Chromate Workers.** W. Höffken. Fortschr. a. d. Geb. d. Röntgenstrahlen **84**: 151–164, February 1956. (In German) (Röntgeninstitut der Medizinischen Universitätsklinik, Leipzig, Germany)

Prior to the institution of hygienic measures, the incidence of chromate lung cancer was high. In one factory alone, 5 workers out of 10 or 12 died of the disease. Since, however, not every exposed person is affected, a certain degree of predisposition to malignant tumor appears to be a prerequisite. The period of latency varies from four to thirty-eight years.

The author reports 4 cases of fatal pulmonary carcinoma which developed in spite of hygienic measures and periodic medical examinations. The right upper lobe was involved in 2 cases, the right lower lobe in the other 2 cases. The average exposure to chromate dust was twenty years.

Chromate carcinoma has all the clinical and roentgenologic features of bronchogenic carcinoma. Histologically, however, fibrosis is noted in the periphery of the tumor, suggesting chronic irritation from dust.

For recognition of the tumor in an early stage the author recommends semiannual health examinations. Unilateral hilar enlargement and increased radiolucency of pulmonary segments as seen on roentgenograms of the chest are especially suspicious of early neoplastic involvement.

Two benign tumors have also been observed in chromate workers, and the possibility of a causal relationship to dust inhalation is discussed.

Prevention of pulmonary changes would be possible only if exposure to chromate dust could be avoided altogether, by complete mechanization of chromate production.

Thirteen roentgenograms; 2 photographs; 1 table.

ERNEST KRAFT, M.D.
Newington, Conn.

**Eosinophilic Granuloma of the Lung.** Milton Virshup and Alfred Goldman. J. Thoracic Surg. **31**: 226–237, February 1956. (City of Hope Medical Center, Duarte, Calif.)

Eosinophilic granuloma is a rare disease of unknown etiology which affects a multiplicity of tissues. While the condition is usually generalized, solitary involvement of bone, of skin, of the gastrointestinal tract, and occasionally of other tissues has been recognized. It has only recently been appreciated that solitary involvement of the lung may occur, and but 4 cases (in 2 reports) could be found in the literature. A fifth case is presented.

The patient was a 15-year-old white boy who was studied because of the finding, on a mobile unit chest x-ray survey, of extensive infiltration throughout both lung fields. He was completely asymptomatic, without cough, expectoration, or hemoptysis. A subsequent roentgenogram revealed an apparent progression of the lesions throughout both lung fields. There were heavy root shadows and scattered mottling by soft nodular densities and areas suggestive of multiple small cystic cavities from the apex to the base bilaterally. The patient was given antibiotics and subsequently a thoracotomy and lung biopsy were performed, establishing the diagnosis of eosinophilic granuloma. Additional antibiotics were given. A roentgenogram obtained nine months postoperatively and nineteen months after the disease was first noted revealed a slight

decrease in the extent of the pulmonary infiltration.

In early stages, roentgenograms of the chest may show a generalized reticulation associated with miliary mottling; later there may be diffuse soft nodular infiltrations of varying size. Large irregular densities may be seen. Fibrotic changes are a constant feature, and in the end stages fibrosis may become extreme. Cysts are sometimes seen which may vary from fine scattered pneumatoceles through generalized emphysema to bullous degeneration or advanced honeycombing. Cysts containing fluid, which alternately fill and empty, have been reported. The effects of gross bronchial obstruction, with localized emphysema followed by atelectasis and pneumonitis, may be noted. There may be extensive mediastinal and hilar lymphadenopathy.

Three roentgenograms; 2 photomicrographs.

HOWARD L. STEINBACH, M.D.
University of California, S. F.

**Hydatid Disease of the Lung.** Madan Lal Aggarwal. Indian J. Radiol. **10:** 10–17, February 1956.

Radiological aspects of hydatid pulmonary disease and some differential diagnostic points are considered. Before establishment of communication of the cyst with a bronchus, the lesion appears as a rounded, homogeneously dense shadow, without surrounding parenchymal reaction. At this stage differentiation from a primary or secondary neoplasm is impossible. Curvilinear calcification in the cyst wall is helpful if present, but is infrequently seen. Cysts occurring adjacent to the chest wall or near the mediastinum require differentiation from mediastinal or pleural cysts and tumors. Ordinarily differential diagnosis can be made only by histologic study. Hydatid lesions are usually single and frequently occur in the posterior part of the right lower lobe. Careful scrutiny of the diaphragm on chest films will occasionally show rounded bulges indicative of similar cysts in the substance of the liver. This may be a helpful diagnostic point.

After communication with a bronchus is established, a striking and reasonably pathognomonic group of changes occur. Air will penetrate between the fibrous capsule of the true cyst ("pericyst") and the outer layer ("ectocyst") to produce a characteristic crescent-shaped air cap. On further collection of air, the ectocyst may be completely separated from the adventitial fibrous capsule, with production of a "cyst-within-a-cyst" or, if fluid is present, a "double arc sign." If the supplying bronchus becomes occluded, atelectasis and infection will occur in the surrounding lung parenchyma, obscuring the characteristic hydatid cyst features and leading to an incorrect radiologic diagnosis of lung abscess. After the inflammatory components in the adjacent parenchyma have cleared, the pathognomonic air cap and cyst will again become visible.

To be differentiated, in addition to lung abscess, are mycotic cavity containing rounded mycetoma, large tuberculous or other cavity with blood clot, and primary neoplasm with cavitation. It is pointed out that repeated films with the patient in various degrees of decubitus will sometimes demonstrate the "cavity-within-a-cavity," allowing definitive diagnosis.

The author reports 2 cases of his own.

Eight roentgenograms; 1 diagram.

JAMES W. BARBER, M.D.
Cheyenne, Wyo.

**Rheumatic Fever Pneumonitis: A Clinical and Pathologic Study of 35 Cases.** Mischa J. Lustok and Joseph F. Kuzma. Ann. Int. Med. **44:** 337–357, February 1956. (Marquette University School of Medicine, Milwaukee, Wisc.)

Pulmonary involvement sufficiently developed to require separation from other diseases was observed in 35 cases of rheumatic fever terminating fatally during an acute phase and studied at necropsy. Similar changes occur in interstitial pneumonitis due to chemical irritation, polyarteritis, uremia, subacute bacterial endocarditis, and in lung tissue adjoining pulmonary abscesses or infarctions. In the rheumatic fever cases, however, the lesions usually far exceed those present in other conditions, both in incidence and magnitude. The authors refer to them as rheumatic fever pneumonitis.

The large number of deaths occurring during the first attack of rheumatic fever complicated by pneumonitis is striking. Respiratory distress, cough, chest pain, cyanosis, and hemoptysis were prominent and out of proportion to the general health status of the patient, the degree of cardiac involvement, and the systemic manifestations of rheumatic fever. Evidence of active rheumatic carditis was noted in all cases.

The character of the x-ray appearance suggests evolution from perivascular increase in density at the hilus, often associated with beading along the bronchovascular markings, to miliary nodular infiltration of the lung parenchyma and ultimately to confluence of lesions to form massive areas of consolidation. In no instance, however, were serial films taken frequently enough to offer proof of this supposition. The appearance of the x-ray lesion *is not pathognomonic.*

The weight of the lungs is increased several-fold, depending principally upon the amount of hemorrhage and edema present. The lung tissue is "rubbery firm" in consistency, showing variations with the amount of hemorrhage, "organization," and degree of aeration. In all cases the diagnosis of rheumatic pneumonitis was first made at autopsy.

The presence of unusually severe respiratory distress, not associated with cardiac and peripheral features of congestive heart failure and non-responsive to supportive management, should arouse the suspicion of rheumatic pneumonitis. Demonstration of suggestive x-ray changes, coupled with the clinical observations, should be sufficient evidence to warrant the diagnosis.

Treatment in the authors' cases included the usual salicylate management of acute rheumatic fever, supportive measures for possible congestive heart failure, and antibiotic therapy where subacute bacterial endocarditis was suspected, but the clinical course was not modified by these agents. No suggestion for effective clinical management of rheumatic fever pneumonitis could be derived from this study.

Five roentgenograms; 1 photograph; 11 photomicrographs; 10 tables.

STEPHEN N. TAGER, M.D.
Evansville, Ind.

**Hamman-Rich Syndrome. Report of a Case Diagnosed Antemortem by Lung Biopsy and Successfully Treated with Long-Term Cortisone Therapy.** C. T. Pinney and H. William Harris. Am. J. Med. **20:** 308–313, February 1956. (C. T. P., Department of Medicine, Fitzsimons Army Hospital, Denver, Colo.)

In 1935, Hamman and Rich described a fatal pul-

monary disease of unknown etiology, subsequently known as the Hamman-Rich syndrome (see Hamman and Rich: Bull. Johns Hopkins Hosp. **74:** 177, 1944. Abst. in Radiology **43:** 405, 1944). In the past, the diagnosis has usually been made at autopsy; it has been suspected clinically in a few cases and in 3, as in the one reported here, was established antemortem by thoracotomy and lung biopsy.

The roentgenographic appearance is not specific. The lungs usually show evidence of extensive infiltration. This may be miliary, reticular, nodular, or coalescent in character. Occasionally, small pleural effusions are seen. In the late stage of the disease the infiltration becomes more extensive and shows a tendency to increased confluence.

In the present case, the patient was symptomatically well, with chest roentgenograms virtually normal seventeen months after initiation of continuous cortisone therapy. This represents the longest clinical remission induced by treatment to be reported in the literature.

Three roentgenograms; 1 photomicrograph.

**Coccidioidomycosis. A Roentgen Study.** Warner A. Peck, Jr., and Samuel S. Romendick. Texas State J. Med. **52:** 86–93, February 1956. (William Beaumont Army Hospital, Fort Bliss, Texas)

*Coccidioides immitis* is a fungus which causes a dust-borne pulmonary disease endemic in the arid portion of the southwestern United States. Most patients with coccidioidomycosis show some roentgen evidence of pulmonary involvement. The picture, however, is not specific. Associated hilar or mediastinal adenopathy, particularly if it appears as pneumonic consolidation disappears, is suggestive of coccidioidomycosis. Associated patches of pneumonia are added evidence in favor of the diagnosis.

Residual lesions from this disease include thin-walled cavities, coin lesions (coccidiomas), persistent regional lymph node enlargement, and unresolved pneumonia. Some believe a smooth, thin-walled cavity without surrounding parenchymal disease is pathognomonic. The coccidioma is found in less than 5 per cent of cases. It is seldom calcified and thus presents a differential diagnostic problem. Unless the development of the lesion has been observed, during the course of a definitely diagnosed case of coccidioidomycosis, resectional biopsy is indicated.

Twenty roentgenograms.

DONALD DEF. BAUER, M.D.
Coos Bay, Ore.

**Pulmonary Changes Occurring in Disseminated Lupus Erythematosus.** Herman J. Moersch, Don C. Purnell, and C. Allen Good. Dis. of Chest **29:** 166–173, February 1956. (Mayo Clinic and Mayo Foundation, Rochester, Minn.)

Lung changes which may be recognized on chest roentgenograms occur in disseminated lupus erythematosus. The clinical diagnosis of the disease can be made from a history of repeated bouts of prolonged fever, arthralgia with toxicity, leukopenia with elevated sedimentation rate, and lupus erythematosus cells in bone marrow and peripheral blood. The present study is based on a series of 54 cases, in 52 of which chest roentgenograms were obtained at some time during the course of the disease. In 34 cases there was roentgen evidence of cardiorespiratory abnormality.

Pleuropulmonary and cardiac disturbances are most frequently encountered in late stages of disease. There may be pleural effusion, pulmonary consolidation from bronchopneumonia or interstitial pneumonia, hemorrhage varying from petechiae to massive lobar involvement, pulmonary edema, and purulent bronchitis.

Pneumonic consolidation, which is scattered in small patches throughout the lungs, and pleural effusion are common but not pathognomonic findings. Cardiac enlargement associated with pleural effusion is not invariable. Non-specific areas of pulmonary fibrosis occur, but are difficult to distinguish from small areas of pulmonary infarction and other lesions. The lung findings are subject to rapid and widespread change and are not sufficiently characteristic to permit a diagnosis without other information about the patient.

Four roentgenograms; 1 table.

DONALD DEF. BAUER, M.D.
Coos Bay, Ore.

**Treatment of Atelectasis by Thoracic Traction.** Edward H. Townsend, Jr., and Lucy Squire. Pediatrics **17:** 250–257, February 1956. (E. H. T., 26 S. Goodman St., Rochester 7, N. Y.)

Segmental or lobar atelectasis may be caused or much exaggerated by weakness of the thoracic wall resulting from injury, or muscular weakness from poliomyelitis or other disease. In such instances inspiratory efforts of the diaphragm in its downward motion are largely negated by inward collapse of the weakened chest wall.

This report deals with a five-month-old child suffering from amyotonia congenita with repeated attacks of right lung atelectasis. Skin traction was applied to the weakened right chest wall by use of adhesive tape and counterweights as the patient lay on his stronger left side. By this method alone extensive atelectasis was successfully treated on several occasions. Improvement in the patient's respiratory status occurred within one or two hours and the right lung was completely aerated in less than twenty-four hours. On one occasion a series of cinefluorographic studies was made and demonstrated nicely the progressive improvement in respiratory mechanics and lung aeration. The authors suggest that such traction for weakened or feeble chest wall segments may be utilized in neonatal or postoperative atelectasis.

Eleven roentgenograms; 2 photographs; 1 diagram.

JAMES W. BARBER, M.D.
Cheyenne, Wyo.

**Unorthodox Clinical and Roentgenological Features of Pulmonary Embolism.** Edgar Leon Dittler. Dis. of Chest **29:** 215–224, February 1956. (146 E. 71 St., New York 21, N. Y.)

Classical features of embolism are absent in many patients whose lives may be in actual jeopardy from this cause. Adequate collateral circulation may prevent hemorrhagic consolidation. Signs of venous thrombi in the lower extremities cannot always be demonstrated. A dangerous thrombus may not be sufficiently adherent and organized to cause circulatory obstruction and inflammation. Chest films offer little aid. Pulmonary infarcts of small size are demonstrated only if the central ray happens to be parallel to the site of the infarct. A lateral view may show the typically wedge-shaped infarct when it is not otherwise apparent. When embolism occurs without infarction, roentgen assistance is of even less value.

Four cases are reported. One patient had experienced episodes of embolism over a period of years, variously diagnosed; another had been discharged from the Armed Forces with a diagnosis of pneumonia, which, however, failed to respond to antibiotics; the third presented right-sided and then left-sided pleurisy on successive hospital admissions; the fourth had suffered two attacks of so-called bronchopneumonia and a third of excruciating precordial pain resembling that of coronary thrombosis.

Fifteen roentgenograms.

DONALD DEF. BAUER, M.D.
Coos Bay, Ore.

**Architectural Reconstruction of the Lung after Partial Resection of Pulmonary Parenchyma.** E. Forster, E. Roegel, M. Assouad, and E. Wolf. J. Thoracic Surg. **31**: 217–225, February 1956. (Strasbourg, France)

Complete re-expansion of the residual parenchyma after partial pulmonary resection is essential for good functional recovery and healing without the complications of empyema or bronchopulmonary fistula.

Three factors play roles in the refilling of the dead space after partial resection of the lung. These are: (1) hyperexpansion of the residual parenchyma, (2) elevation of the diaphragm, and (3) displacement of the mediastinum.

It has been found that it is easier for the organism to obliterate a dead space by shift of a mobile organ, such as the diaphragm or mediastinum, than by hyperexpansion of the parenchyma, except when the pulmonary tissue is healthy and elastic, which is rare in the adult.

To insure refilling of the hemithorax, the authors bring the lung in close contact with the bony structures, leaving it distant from the mediastinum and diaphragm. In order to accomplish this, they free the lung completely, open the interlobar fissures, rotate a segment or a lobe around its bronchial axis into the required position, and fix it by sutures. If necessary, a few sutures are used to fix the lung to the chest wall. This method has been employed in 136 patients undergoing lobectomy or segmental resection for various indications. The results have been satisfactory. Postoperative bronchograms in these cases have shown no evidence of bronchial kinking.

Nine roentgenograms; 4 drawings.

HOWARD L. STEINBACH, M.D.
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**Bronchography. Use of Aqueous and Oily Suspensions of Dionosil.** Alfred M. Tocker. J. Kansas M. Soc. **57**: 62–64, February 1956. (304-5 KFH Bldg., Wichita, Kans.)

The author summarizes from the literature the advantages of Dionosil as a contrast medium for use in bronchography: (1) rapid disappearance from lungs; (2) infrequent alveolar filling; (3) improvement in detail; (4) minimal irritation; (5) ample exposure time for films; (6) no risk of iodism; (7) safety in the presence of tuberculosis; (8) introduction by any of the presently recognized routes; (9) no necessity for special radiographic facilities; (10) increased scope of bronchography.

The following disadvantages are listed: (1) requirement of special care in anesthesia; (2) technical difficulties in handling the medium; (3) occasional pyrexial reaction; (4) dyspnea.

Two roentgenograms.

**Operative Thoracic Ductography.** Allan Stranahan, Ralph D. Alley, Harvey W. Kausel, and Thomas S. Reeve. J. Thoracic Surg. **31**: 183–195, February 1956. (Albany Medical College, Albany, N. Y.)

In 30 instances, the thoracic duct has been studied by proximal and distal injection of radiopaque material at the level of the diaphragm. The contrast substance was introduced by means of small plastic catheters with which both ends of the divided duct had been cannulated. In 27 cases these studies were performed on fresh postmortem subjects; in the remaining 3 cases observations were made at the time of surgery.

The anatomic variations could be classified in five general groups. In 1 instance the duct was entirely right-sided. In 9 cases the duct was essentially single throughout its course. In 10, it was single at and below the level of the tenth thoracic vertebra, although there was a double duct or 'insular" pattern in the upper thoracic region. In 5 cases many channels were noted at the diaphragm, with an essentially single representation above. In 5 there were two distinct ducts at and below the level of the tenth thoracic vertebra.

The observation that roughly one-third of the thoracic ducts have two or more trunks at the level of the diaphragm is of practical significance in the surgical treatment of chylothorax, and a satisfactory method of recognizing such ducts at the time of operation appears to be of distinct value.

The surgical management of traumatic chylothorax is well established, and recent reports indicate a more aggressive attitude, favoring earlier surgical intervention when lesser measures are ineffective.

Though less frequently encountered, spontaneous chylothorax not the result of neoplasm is also amenable to surgical correction and presents essentially the same problems in management as do the traumatic cases.

Sixteen roentgenograms, with 9 line drawings; 1 diagram.

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## THE CARDIOVASCULAR SYSTEM

**The Relative Value of Electrocardiography and Photoroentgenography for Cardiac Surveys.** A. Calhoun Witham and H. B. Jones. Am. Heart J. **51**: 186–198, February 1956.

The authors studied a group of 218 individuals, 126 cardiac patients and 92 without heart disease, with 4-lead electrocardiograms and 4 × 6-inch photoroentgenograms, for the purpose of determining which would serve best for mass survey detection of cardiovascular lesions. Tables and charts show the results.

The electrocardiographic study detected a satisfactory number of cardiac conditions (83 per cent) but gave a relatively high percentage of false positives in the normal group (11 per cent).

From the x-ray standpoint, cardiac enlargement was used in an indicator separating the cardiac from the normal patients. Use of the cardiac-thoracic measurement (at the level of the fourth anterior interspace, right side) was found to yield fewer false positives than the Ungerleider and Clark tables and to compare favorably with the latter method in the detection of cardiac disease.

Most cases with cardiac enlargement also showed abnormal contours, as would be expected, but the impression of an abnormal contour was so strengthened by a definite increase in the transverse cardiac diameter that it appears quite possible that most radiologists would fail to report unusual contours observed in a mass survey unless their suspicions were supported by cardiomegaly.

Upon a comparison of the two methods, the following observations were made: (1) Evaluating cardiac contour without cardiac enlargement increased the positives in the cardiac group, but multiplied the false positives threefold in the normals. (2) The electrocardiogram detected more cardiac patients than the cardiothoracic ratio alone, with only a slight increase in false positives. (3) Although the electrocardiogram detected fewer cardiac patients than the cardiothoracic ratio and contour reading, the false positives were less (about half). (4) The combination of electrocardiogram and cardiothoracic ratio was as good as contour reading plus cardiothoracic ratio, and gave fewer false positives. (5) The combination of cardiothoracic ratio, contour reading, and electrocardiography gave the best detection rate—92 per cent—but an extremely high number of false positives—29 per cent.

Eighteen cardiac patients gave normal x-ray findings, and 22 normal electrocardiographic findings; 10 were normal both roentgenologically and electrocardiographically. The combination of cardiothoracic ratio and 4-lead electrocardiograms yielded a higher detection rate, 87 per cent, than either alone, with 16 per cent false positives.

The combination of a 4-lead electrocardiogram and photoroentgenogram has the advantage of demonstrating some cases of non-cardiac pathology. The electrocardiogram would appear to be more practical for a survey limited to heart disease.

Eight roentgenograms; 3 charts; 3 tables.

HENRY K. TAYLOR, M.D.
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**Evaluation of Aortic Occlusion by Aortography.** William J. Reedy, Bohdan Koszewski, and Paul Murphy. Ann. Int. Med. **44:** 283–291, February 1956. (Creighton University School of Medicine, Omaha, Nebr.)

The technic of aortography employed by the authors is essentially that of Smith, Rush, and Evans (J.A.M.A. **148:** 255, 1952. Abst. in Radiology **60:** 627, 1953). A 6-inch, 18-gauge needle is introduced below the left twelfth rib, 6 to 8 cm. lateral to the spinous process of the corresponding vertebra. It is directed cephalad, medially and anteriorly, to strike the body of the eleventh or twelfth vertebra. To visualize the renal vessels the needle should strike the body of the eleventh thoracic vertebra. At this point, it is slightly withdrawn and redirected more medially until it slides off the anterolateral aspect of the vertebral body. The stylet is removed and the needle is advanced through the aortic wall. Sufficient force is exerted on the syringe barrel to assure the delivery of the contrast material within three or four seconds. The film is obtained during injection of the last 5 c.c. Timing is extremely important, as the medium is propelled quickly by the aortic blood flow.

This procedure has proved valuable for determining the topography of vascular lesions when clinical evidence suggests their presence and is a necessary measure for the precise visualization of the location and extent of segmental obstruction of the aorta and its major branches prior to its definitive surgical treatment. Other possibilities of usefulness are in the diagnosis of splenic artery aneurysms, calcification in the abdomen, and in cysts and neoplasms of the pancreas not identifiable by conventional studies.

Five roentgenograms.

STEPHEN N. TAGER, M.D.
Evansville, Ind.

**Thoracic Aortography By Means of a Radiopaque Polythene Catheter Inserted Percutaneously.** Per Ödman. Acta radiol. **45:** 117–124, February 1956. (Roentgen Department, Södersjukhuset, Stockholm, Sweden)

A new type of radiopaque polythene catheter has been devised by the author with the usual distal opening, but with additional side-holes for 4 to 5 cm. immediately proximal to the extremity to insure the smallest possible recoil on injection of the contrast medium. Two sizes of catheter have been used, with internal diameters of 1.25 and 1.55 mm. and external diameters of 2.62 and 2.75 mm.

The catheter is introduced into the femoral artery by Seldinger's method (Acta radiol. **39:** 368, 1953. Abst. in Radiology **62:** 466, 1954) with the aid of a leader, size PE 160, and is maneuvered under fluoroscopy until its tip lies in the middle part of the ascending aorta. The distal end is distinctly curved to facilitate guiding through the aortic arch. The contrast medium is injected by means of a pressure apparatus at a rate of only 20 milliliters per second, but good visualization is obtained.

No failures or severe complications have occurred in 30 cases examined with this technic.

Six roentgenograms; 1 drawing.

P. W. MATHEWS, M.D.
Bowman Gray School of Medicine

**Paraplegia, a Rare Complication of Translumbar Aortography.** Benjamin S. Abeshouse and Antonio T. Tiongson. J. Urol. **75:** 348–355, February 1956. (B. S. A., 100 W. Monument St. Baltimore 1, Md.)

The authors report the fourth case in the world literature of complete paraplegia following translumbar aortography. Thirty cubic centimeters of 70 per cent Urokon were introduced into the abdominal aorta according to the usual procedure, with all customary precautions, including a preliminary trial injection of 2 c.c. of the medium. The complication of paraplegia, with areflexia, thermanesthesia, and loss of bladder and rectal control, developed six hours later.

The patient died of generalized carcinomatosis about six months after the aortographic procedure, the paraplegic symptoms having shown slight improvement in the interval. Autopsy was performed, and the spinal cord was removed intact for microscopic study. The authors believe that the paraplegia was the result of direct toxic effect of 70 per cent Urokon on the spinal cord *via* the spinal artery. No thrombosis of the anterior spinal artery or its branches was seen. The cord showed demyelization, which was more intense in the thoracolumbar region, involving the ventrolateral areas of the lateral funiculi and most of the central funiculus.

Two roentgenograms; 2 photomicrographs.

J. D. GERLACH, M.D.
Cleveland City Hospital

**Acute Pancreatitis Following Translumbar Aortography. Case Report with Autopsy Findings Seven Weeks Following Aortogram.** Alan S. Robinson. Arch. Surg. 72: 290–294, February 1956. (Second Medical Division, Bellevue Hospital, New York, N. Y.)

Translumbar aortography was performed on a patient being studied for thrombosis of the lower abdominal aorta. Twenty cubic centimeters of 70 per cent Urokon were injected and found on roentgenography to have entered the celiac artery. Immediate reinjection into the aorta demonstrated the occlusion just below the origin of the renal arteries and produced a high concentration of Urokon in the kidneys.

Signs and symptoms of severe acute pancreatitis developed four hours later. This was followed by a transient elevation of the blood urea nitrogen and anesthesia and paresis of one leg. Seven weeks following aortography the thrombosed aorta was replaced by a graft. At that time extensive fat necrosis was noted throughout the abdomen.

The patient died of a cerebrovascular accident on the second postoperative day and autopsy demonstrated a fresh thrombus throughout the aortic graft and scattered areas of non-suppurative pancreatic necrosis. The untoward effect on the pancreas is attributed to an excess concentration of the contrast medium in the celiac axis. This might have been avoided by injection of a small amount of medium to check the position of the needle.

Two roentgenograms; 1 photograph; 1 photomicrograph.

RICHARD E. BUENGER, M.D.
Chicago, Ill.

## HERNIA

**Hiatus Hernia in Children. A Radiologic-Clinical Study Comprising 58 Cases.** Gregers Thomsen. Acta radiol. Suppl. 129, 1955. (Rigshospitalet, Copenhagen, Denmark)

The author thoroughly analyzes 58 cases of hiatus hernia in children diagnosed at the Rigshospitalet, Copenhagen, in the period 1922 to 1954. Half the patients were under one year of age when first admitted. The sex incidence was about equal.

The rather voluminous literature on hiatus hernia, covering the anatomy, pathogenesis, classification, and radiological features is reviewed at some length. Much of this background data relates to adult findings, as little has been written about the entity in children. A classification based on the radiologic features is employed, only two main types being recognized: paraesophageal hernia and sliding hernia. The latter is subdivided into sliding hernia without esophageal change and sliding hernia with change. Barrett's congenital short esophagus, an anomaly in which the lowest portion of the gullet is lined with gastric mucosa, although a clinical entity, cannot be radiologically diagnosed, as it does not differ from sliding hernia with esophageal change.

Radiography is required to diagnose hiatus hernia in a child, as the past history and clinical findings are seldom sufficiently characteristic. The main symptoms are vomiting, hematemesis, dysphagia and pain, weight loss, and defective development. Only one of the author's patients was asymptomatic. In most cases symptoms began shortly after birth, being more pronounced in sliding hernia. Pain and dysphagia were confined almost exclusively to cases with esophageal change. Sliding hernias without esophageal change were demonstrated exclusively in children under two years; those with esophageal change as well as those of the paraesophageal group occurred somewhat later.

The technic of examination is as follows: A barium suspension of 25 to 30 gm. of barium sulfate in 100 c.c. of water is employed. While the patient is feeding, films are made in the dorsal recumbent and right and left anterior oblique positions. At least four to eight exposures are required, as one or two films can give highly erroneous impressions, particularly in the first months of life. The patient is then turned prone, and an oblique view is obtained with the left side raised. This affords good air relief of the mucosal folds of the fornix and lower esophagus. The examination concludes with fluoroscopy and roentgenography in steep Trendelenburg position (45 to 90°) in an attempt to demonstrate regurgitation.

To aid in the establishment of criteria, 145 normal children were studied. The x-ray appearance of the esophagus in adults and children was found not to differ greatly, the most essential difference being the ability of the child's esophagus to dilate considerably, particularly in the lower third. This feature becomes less pronounced after two or three years of age. The phrenic ampulla is considered a physiological rather than anatomic dilatation. It appears only during the process of deglutition and not from reflux into the esophagus. Neither it nor the cardial antrum, which is small in children, is believed to constitute a problem in differentiation from hernia in this age group. Of prime importance is the fact that in normal children reflux of barium into the esophagus could not be visualized.

Four criteria of hernia are presented: (1) demonstration of gastric mucosa in the sac (in large herniae the folds are irregular; in smaller ones they appear as four to ten parallel folds); (2) a wide hiatus through which the folds pass upward; (3) obliteration of the cardial incisura; (4) regurgitation of barium. In all cases with sliding hernia examined in the Trendelenburg position, regurgitation could be demonstrated. In numerous instances, regurgitation was into the esophagus as well as into the hernia. In paraesophageal hernia there was regurgitation into the hernia only, as the closing mechanism of the cardia is intact.

Factors cited as responsible for the normal closing mechanism include a sphincter in the lower esophagus, position of the lower esophagus in relation to the liver, the pinch-cock action of the diaphragm, and the oblique opening of the esophagus into the stomach, with formation of the plica cardiae. The author favors the last named factor as being the most important. In sliding hernia the closing mechanism is incompetent, and regurgitation of gastric contents may result, causing esophagitis. Esophageal shortening was previously considered the prime factor and actual cause of the hernia. The results of operation in this series convinced the author that the reverse is the case; the sliding hernia is primary and the shortening secondary.

The cause of paraesophageal hernia is presumably congenital. The hiatus is large, and this is attributed to persistence of the right pneumato-enteric recess. Sliding hernia is probably acquired, and is due to abnormal fixation—or lack of fixation—of the cardial region of the stomach. It is presumably not present before birth but develops as a consequence of the change in pressure in thorax and abdomen.

Only 5 of the hernias in the author's series were paraesophageal. Of the 53 sliding hernias, some 50 per cent showed esophageal change, though this figure cannot be considered indicative of the real occurrence, since sliding hernia without esophageal change had been chiefly diagnosed during recent years. The esophageal changes are divided into three subgroups: ulcer and fibrosis, fibrosis, and spasm, demonstrated in 13, 5, and 8 patients respectively.

In 27 instances there was a sliding hernia only. The author believes that this group includes cases which have been interpreted in the literature as cardioesophageal relaxation. In many instances, massive barium filling can render demonstration of the hernia impossible unless the relief pattern of the mucosa is obtained in the prone position.

Treatment recommended varies with the age of the patient and type of hernia. In all cases of paraesophageal hernia, herniotomy should be done, owing to the possible complications. In sliding hernia without esophageal change, conservative treatment, consisting in measures to reduce the regurgitation, should be employed initially. Only if this has failed, and the child is over two, is herniotomy indicated, in an attempt to reestablish normal function of the cardia. When esophageal changes have developed, conservative treatment may in some cases cause the patient to become almost symptomless. If, however, there is pronounced stenosis, a large ulcer with risk of perforation, or congenital short esophagus, even herniotomy will seldom lead to recovery and segmental excision with anastomosis is the procedure of choice.

This monograph of some 200 pages includes individual reports of all 58 cases, as well as 161 roentgenograms.

C. M. GREENWALD, M.D.
Cleveland Clinic

**Evaluation of the Various Methods of Demonstrating a Hiatus Hernia.** James W. Boyd, J. Raymond Harris, Edward B. Butler, and S. W. Donaldson. Am. J. Roentgenol. **75:** 262–268, February 1956. (S. W. D., St. Joseph Mercy Hospital, Ann Arbor, Mich.)

A systematic evaluation of the various maneuvers for demonstration of hiatus hernia is undertaken. In a series of 1,500 consecutive gastrointestinal examinations the positions and maneuvers recommended by different workers were employed in definite sequence for each study, and that maneuver which first revealed the hernia was noted. Thirty-five diaphragmatic hernias through the esophageal hiatus were discovered (2.3 per cent), 10 during examination of the patient in an erect position. Sixteen appeared with the patient supine and 5 when the patient was turned into the prone position. One of the remaining 4 was first seen after performance of the Valsalva test and 3 were visualized after a "straight leg raising" maneuver. This latter is accomplished by placing the patient supine and having him lift both heels off the table while he continues to breathe. It is significant that the Trendelenburg position, forced coughing, and pressure on the abdomen failed to demonstrate a single hernia not already shown, even though these three maneuvers were tried early in the systematic study.

Presumably a hiatus hernia results when increased intra-abdominal pressure causes protrusion of the stomach through the weakest area of the diaphragm. Therefore, a maneuver which will increase intra-abdominal pressure without matching it with an increased intrathoracic pressure should be most successful in demonstrating these hernias. The straight leg raising test described here meets these conditions. The Valsalva test, coughing, and pressure on the abdomen fail because they usually result in increased intrathoracic as well as intra-abdominal pressure, but this argument does not explain failure of the Trendelenburg position.

Seven roentgenograms. JAMES W. BARBER, M.D.
Cheyenne, Wyo.

**Subcostosternal Diaphragmatic Hernia, with Report of Five Cases.** Richard A. Betts. Am. J. Roentgenol. **75:** 269–276, February 1956. (252 Paulsen Medical and Dental Bldg., Spokane 1, Wash.)

Subcostosternal hernia is known also as foramen of Morgagni hernia, retrosternal, parasternal, substernal, and anterior diaphragmatic hernia. The foramina of Morgagni or Larrey's spaces are small triangular areas limited anteriorly by the sternum, medially by the sternal portion of the diaphragm, and laterally by its costal portion in the region of attachment to the seventh costal cartilage. These areas are filled with loose areolar and connective tissue and form congenitally weak areas through which herniation may occur.

The usual roentgen findings are outlined and 5 cases are reported in moderate detail. All of them occurred in women in their sixties and all were confirmed by thoracotomy. Each of the patients had mild to moderate symptoms in the epigastrium or low sternal region, usually described as a sense of pressure or discomfort, of an intermittent and non-characteristic nature. The hernias were found in all cases by routine roentgen examination of the chest supplemented in most instances by gastrointestinal studies. At thoracotomy all were in the right cardiophrenic angle anteriorly. They all contained omentum with prominent fatty components. In one instance a loop of colon was included in the hernia and this case showed an air bubble within the smooth soft-tissue mass on chest filming.

The importance of subcostosternal hernias is said to lie in their potential complications, namely incarceration, strangulation, or obstruction, particularly if some portion of the gastrointestinal tract is included in the hernia.

Eleven roentgenograms. JAMES W. BARBER, M.D.
Cheyenne, Wyo.

**Multiple Pharyngeal and Esophageal Diverticula, Hiatal Hernia of the Stomach, and Chalasia of Esophageal Cardiac Junction. Case Report.** Leon Solis-Cohen, Matthew Ersner, and Paul S. Friedman. Am. J. Roentgenol. **75:** 242–245, February 1956. (P. S. F., 1422 Chestnut St., Philadelphia 2, Penna.)

A white female of sixty-five complained of discomfort in the left side of her throat and a peculiar, audible crackling noise during swallowing. X-ray studies revealed a diverticulum, 3 × 5 cm., arising from the posterolateral aspect of the hypopharynx (Zenker's type), two traction-type diverticula at the level of the aortic arch, and an epiphrenic-type diverticulum extending from the anterior aspect of the distal esophagus. In addition, there was an esophageal hiatus hernia with reflux from the stomach into the lower esophagus. The authors postulate the possibility of a

general muscular weakness of the esophagus, with resulting diverticula and hernia formation.

Nine roentgenograms. PAUL MASSIK, M.D.
Quincy, Mass.

## THE DIGESTIVE SYSTEM

**The Lower Esophageal Ring.** Richard Schatzki and John E. Gary. Am. J. Roentgenol. **75:** 246–261, February 1956. (R. S., 1180 Beacon St., Brookline 46, Mass.)

This is a supplement to an earlier paper, in which the authors described a clinical entity which they designated "lower esophageal ring" (Am. J. Roentgenol. **70:** 911, 1953. Abst. in Radiology **63:** 601, 1954).

The lower esophageal ring is a thin, symmetrical diaphragm protruding into the lumen of the lower esophagus in a plane vertical to the longitudinal axis. The lumen at the ring varies in diameter from 3 to 38 mm. and is quite constant in a given case.

The incidence of rings, when specifically sought for, was 17 in 368 patients undergoing gastrointestinal examination. The authors have seen altogether 21 cases. Not all patients have dysphagia, the occurrence of this symptom being dependent upon the diameter of the ring.

The ring is best visualized in the right oblique prone position, with the esophagus distended and filled with barium. Endoscopically the only abnormality noted has been narrowing of the esophagus, and not all cases have demonstrated this. There may be an associated hiatus hernia, and in several cases Zenker's diverticula arising from the posterior wall of the lower hypopharynx were present. The only symptomatically similar condition is Plummer-Vinson's syndrome, where the web is to be found in the upper esophagus. Also to be differentiated are transient esophageal contractions, which vary in length and location, hiatus hernia, which also varies in size and location and has a different shape, and esophagitis, in which the narrowing is asymmetrical.

The nature of the ring is still in doubt. Operation in a case reported by Inglefinger and Kramer (Gastroenterology **23:** 415, 1953. Abst. in Radiology **62:** 135, 1954) revealed thickening of the muscular layer. One of Schatzki's patients showed only thickening of the esophageal mucosa and an associated hiatus hernia, with no muscular thickening.

No treatment is necessary, but the patient must avoid taking excessively large bits of solid food.

Forty-seven roentgenograms; 1 chart.
PAUL MASSIK, M.D.
Quincy, Mass.

**Plummer Vinson Syndrome.** Charles F. Hutton. Brit. J. Radiol. **29:** 81–85, February 1956. (Central Middlesex Hospital, London, N. W. 10, England)

Plummer-Vinson syndrome is a well known clinical condition characterized by dysphagia associated with simple hypochromic anemia. Other features which may be present include smooth, often sore tongue, dry mouth, spoon-shaped brittle nails, and angular stomatitis. The author's series, seen between 1947 and 1954, consists of 24 cases, of which 23 were in females. Duration of the dysphagia varied from one month to eleven years.

A lateral roentgenogram with barium revealed in every instance a characteristic web filling defect in the anterior wall of the pharynx just below the lower border of the cricoid cartilage. When the pharynx above was well distended, this indentation could also be demonstrated on the postero-anterior film. Immediately below the web it was often possible to identify a segmental zone of constriction of the upper esophagus about 1/2 inch in length. The lower limit of this narrowed segment may be demarcated from the normal esophagus by a second web.

The cause of the development of this pharyngeal web is not known with certainty. Necropsy findings are rare. In one patient, who died of pneumonia, the epithelium showed evidence of chronic inflammation, with marked degeneration of the superficial and middle layers.

Satisfactory clinical response is not necessarily followed by disappearance of the web, and it is believed by some that the web formation is less often the cause of obstruction than would appear from the films. Esophagoscopy may result in rupture of the web and a return to normal appearance.

The association of Plummer-Vinson syndrome and hypopharyngeal cancer in women has been stressed by Welin (Brit. J. Radiol. **26:** 218, 1953) and others. He regards Plummer-Vinson syndrome as precancerous and observes his patients at six-month intervals indefinitely. In some instances where carcinoma has developed, the tumor arose above the web, showing that the whole mucous membrane is affected. In the present series 1 patient, a woman of thirty-nine, was found to have a post-cricoid carcinoma some thirty months after the initial diagnosis of Plummer-Vinson syndrome.

Cases of carcinoma developing in other parts of the esophagus have also been reported, but the author believes this association to be coincidental. The only male in his series, with a history of Plummer-Vinson syndrome dating back seven years, had a carcinoma of the middle third of the esophagus.

An addendum reports, without comment, the case of a 74-year-old male with typical clinical findings but with a web constriction arising posteriorly at the pharyngo-esophageal junction rather than anteriorly. After dilatation the web disappeared, but a small diverticulum developed.

Seven roentgenograms; 1 photomicrograph; 1 table. C. M. GREENWALD, M.D.
Cleveland Clinic

**Water-Soluble, Nonabsorbable Radiopaque Mediums in Gastrointestinal Examination.** Lawrence A. Davis, Kee-Chang Huang, and Everett L. Pirkey. J.A.M.A. **160:** 373–375, Feb. 4, 1956. (L. A. D., 323 E. Chestnut St., Louisville 2, Ky.)

In selected cases the authors have used the urinary contrast media, sodium acetrizoate (Urokon) and diatrizoate sodium (Hypaque), instead of a barium preparation for gastrointestinal examination. These have the advantages of being opaque, soluble, relatively non-absorbable, non-toxic in body cavities, miscible with blood, and of low viscosity, thereby affording better visualization of the mucosal pattern.

The chief objection to the use of these iodides is their expense. It would be costly indeed to fill a hollow viscus with the material, particularly in an adult. The bitter taste is objectionable, but this difficulty is overcome when the medium is instilled through an already present gastric tube. Both Urokon and Hypaque traverse the intestine rapidly; they are hygroscopic and thus conducive to a mild diarrhea, which

may be a blessing in disguise when a barium enema is desired shortly afterward.

The authors use a concentration varying from 35 to 70 per cent in adults, and 50 per cent or less in children. There is a better delineation of gastric mucosa both fluoroscopically and in compression films. It has been possible to outline small duodenal ulcers that escaped detection in the conventional examination. The site of a small bowel obstruction can be ascertained through an intestinal tube without fear of further obstruction by inspissated material. Because of its miscibility with blood, the medium should be able to outline bleeding points during upper gastrointestinal examination.

In infants there is more rapid outlining of the distal antrum in pyloric stenosis, with less danger of aspiration of the stomach contents. In these young patients it should be possible to detect small tracheoesophageal fistulae with this less viscous medium.

Seven roentgenograms. SAUL SCHEFF, M.D.
Boston, Mass.

**Pseudo-Ulceration of the Stomach and Duodenum Produced by Traction Diverticula.** John W. Wilson and Ben J. Wilson. Am. J. Roentgenol. **75:** 297–307, February 1956. (J. W. W., 5201 Harry Hines Blvd., Dallas, Texas)

The differentiation of traction diverticula from ulcers is of considerable importance, more especially as the demonstration of a gastric ulcer which fails to heal in a given period of time is accepted as an indication for exploratory laparotomy by many surgeons. One of the characteristics of traction diverticula is constancy of deformity, which can easily be misinterpreted as due to a medically refractory ulcer. The radiologist's familiarity with the conditions and ability to differentiate them may save the patient from formidable surgical procedures or from a protracted dietary regimen.

The authors describe a traction diverticulum as a localized evagination of the stomach or duodenum produced by fibrous bands adherent to the serosal surface and exerting an outward pull on the wall. Pathogenetically, an episode of inflammation results in a proliferative fibroplastic response, and consequent contraction of the fibrous strand distorts the wall of the stomach and duodenum. The lesions may represent a residual effect of perforation of peptic ulcers.

This paper includes the case histories of 5 patients, in whom 7 gastric and duodenal diverticula were demonstrated. Each patient was subjected to repeated roentgenologic study of the gastrointestinal tract and all but one had subsequent operative procedures by which the diagnosis was established.

Like a benign ulcer, the traction diverticulum is seen as a niche or pocket projecting beyond the limits of the gastric or duodenal lumen. The extraluminal projection is, however, more triangular in shape, with a broad base and blunt apex pointing outward. The configuration of the pouch may change with palpation and peristalsis, and the contour may vary on successive examinations. The overhanging edges seen in benign ulcers were not demonstrated in any of the cases presented. Radiation of the gastric rugae is not a conspicuous feature. No incisura was observed, and there was no local tenderness elicited on deep palpation.

Congenital or acquired pulsion diverticula differ from traction diverticula in their location. In the stomach these have a predisposition for the cardia, near the esophageal entrance; the most common site in the duodenum is near the papilla of Vater. None of the gastric or duodenal traction diverticula presented by the authors occurred in these areas. The roentgen features of congenital or acquired pulsion diverticula and traction diverticula also differ. As opposed to the traction type, other diverticula project farther beyond the wall of their origin and have a long, narrow neck with a dilated outer end resembling a mushroom. Since the narrow neck impedes emptying, these diverticula may retain barium for many hours. The traction diverticula, being shallow with a broad base, empty more readily, and barium is not retained for any protracted period.

Twenty-four roentgenograms.

FRANK T. MORAN, M.D.
Auburn, N. Y.

**Congenital Mucosal Diaphragm of the Pyloric Antrum.** W. T. Swartz and R. D. Shepard. J. Kentucky M. A. **54:** 149–151, February 1956. (W. T. S., 319 S. Limestone St., Lexington, Ky.)

A case of congenital mucosal diaphragm of the pyloric antrum is reported. The patient was a 55-year-old woman with a history of several years of upper abdominal fullness and intermittent vomiting. Barium-meal examination showed a persistent constricting defect in the antrum about an inch from the pylorus, the deformity appearing in all positions and at all angles throughout the examination. Although the barium passed the partial occlusion with hesitation, no evidence of actual obstruction was seen. The actual nature of the constriction could not be determined roentgenologically. Operation revealed a congenital antral band in the form of a membrane covered with mucosa and containing a central perforation measuring 1 cm. in diameter. A Heineke-Mikulicz pyloroplasty was performed.

This is the third such case to be reported. The authors believe that, while these lesions are relatively infrequent, their presence should be considered in cases of antral deformity.

Two roentgenograms.

**Routine Barium-Gas Examination of the Duodenal Bulb.** C. L. Hinkel and G. A. Moller. Am. J. Roentgenol. **75:** 291–296, February 1956. (C. L. H., The George F. Geisinger Memorial Hospital, Danville, Penna.)

The authors review the barium and barium-gas technic previously described by Hampton (Am. J. Roentgenol. **38:** 565, 1937) for examining the first portion of the duodenum.

The esophagus, stomach and duodenum are first examined in the routine manner, including pressure films of the stomach and duodenal bulb in the erect position. The patient is then given 1 ounce of a carbonated beverage, and the x-ray table is brought to the horizontal position. The patient is rolled to the right and to the left until the gas rises into the antrum and bulb. A left lateral position is used if the gas does not enter the bulb promptly.

Spot films are made in rapid succession, and the remainder of the conventional upper gastrointestinal examination follows.

The weight of the barium in the fundus and pars media pulls the stomach to the left and exerts traction on the duodenum. The second portion of the duodenum is fixed retroperitoneally and there is stretching

of the bulb, with resultant straightening of the duodenal "elbow" (the posterior angulation at the junction of the first and second portions of the duodenum).

Films of good diagnostic quality show the bulb thinly coated with barium, distended with gas, and slightly elongated. The technic is especially useful in demonstrating craters of the posterior wall; when deep palpation and compression are contraindicated (bleeding); when the patient cannot stand; and when there is a high, inaccessible bulb.

The discussion is illustrated by numerous excellent roentgenograms clearly illustrating the value of the barium gas technic in selected cases.

Fourteen roentgenograms; 1 drawing.

FRANK T. MORAN, M.D.
Auburn, N. Y.

**The Anatomical Basis for the Epsilon Sign of Frostberg.** O. Arthur Stiennon. Am. J. Roentgenol. **75:** 282–290, February 1956. (110 E. Main St., Madison, Wisc.)

Frostberg's sign is a double scalloping of the concave portion of the descending duodenum in the region of the ampulla of Vater demonstrable on barium examination. It has also been called "the reversed figure 3 sign," and more exactly, "the epsilon (ε) sign." The author attempts to explain the anatomical features which produce this appearance and to assess the importance of its demonstration. A minute analysis of the radiographic findings and their correlation with the anatomy of this region lead to the conclusion that the upper limb of the ε is produced by enlargement of the minor papilla of Vater and that the lower, usually larger, limb represents enlargement of the major papilla. The central stem or bar of the ε is the result of a small pocketing of barium between the two enlarged papillae and the medial duodenal wall and not of barium in the opening of the papilla, although this is sometimes seen.

It is concluded that the ε sign ordinarily indicates pathological enlargement of both of the papillae, although occasionally it is demonstrable in normal individuals. In the author's experience the most common cause is papillary edema, usually associated with duodenitis referable to duodenal ulcer. He has seen the epsilon sign completely disappear after patients have been placed on anti-ulcer management. Should either of the limbs of the ε be irregular, or enlarged beyond their usual location in the duodenum, one should be suspicious of neoplasm in the papilla of Vater, the distal common bile duct, or the adjacent head of the pancreas.

The author feels that the epsilon sign is much more frequent than would be suspected from the literature and is perhaps frequently overlooked in routine examinations of the upper gastrointestinal tract because of failure of the examiner to scrutinize the descending duodenum carefully when it is well filled with barium.

Twenty-one roentgenograms.

JAMES W. BARBER, M.D.
Cheyenne, Wyo.

**Peptic Ulcer of the Second Part of the Duodenum.** C. W. Clark. Ann. Surg. **143:** 276–279, February 1956. (Manitoba Clinic, Winnipeg, Canada)

Peptic ulcer occurring in the descending, post-bulbar, or second portion of the duodenum is not uncommon. Necropsy evidence as reported in earlier publications places the incidence of post-bulbar ulcer between 5 and 20 per cent.

The clinical history is often that of atypical severe epigastric pain, radiating to the back, unrelieved by dietary measures, and associated with vomiting. Hemorrhage is common.

The most characteristic radiological finding is an eccentric narrowing of the second part of the duodenum below the bulb and above the bile papilla. A crater, if large, may be visualized. It is usually on the medial wall. It may simulate a diverticulum, but the crater is always associated with narrowing. Obstruction may be present, with retention.

The surgeon may miss the ulcer at the time of exploration, as was done in 1 of the 4 cases reported in this article.

Four roentgenograms.

HOWARD L. STEINBACH, M.D.
University of California, S. F.

**Roentgen Aspects of the Papilla of Vater.** Maxwell H. Poppel and Harold G. Jacobson. Am. J. Digest. Dis. **1:** 49–58, February 1956. (M. H. P., 33 East End Ave., New York, N. Y.).

This study on the papilla of Vater is based on roentgen and microscopic studies of 100 normal postmortem specimens and on surgical and postmortem follow-ups in many cases of vaterian disease.

In the normal specimens the location of the major papilla was consistently on the medial wall toward the posterior aspect of the mid-descending duodenum. The average length of the major papilla was 1.5 cm., the average width 0.5 cm. A minor papilla existed in all cases and with 3 exceptions was smaller than the major papilla. A transverse fold of the mucosa forming a hood above the papilla was a regular finding.

While a normal papilla is regular and smooth and is surrounded by constant mucosal folds, irregularity is a sign of disease. Any break, delay or speed-up in the peristaltic wave about the papillary area is also a sign of morbidity.

A simple pathological classification of vaterian diseases is included, the main headings being congenital large papilla, primary benign tumors, primary malignant tumors, secondary malignant tumors, and inflammatory disease.

Eleven roentgenograms; 2 photographs.

ALEXANDER R. MARGULIS, M.D.
University of Minnesota

**Retroperitoneal Rupture of the Duodenum Caused by Blunt Trauma, with a Case Report.** Thomas P. E. Rothchild and Alfred H. Hinshaw. Ann. Surg. **143:** 269–275, February 1956. (VA Center, Wichita, Kans.)

Rupture of the duodenum constitutes about 10 per cent of all cases of intestinal rupture occurring as a result of trauma without perforation of the abdominal wall. Of the duodenal injuries, 25 to 33 per cent have been reported as being retroperitoneal.

The mechanism of the rupture may be one of four types: (1) crushing of the duodenum as it is fixed rigidly against the vertebral bodies; (2) tearing by a tangential force applied to the rigid and fixed retroperitoneal attachments; (3) bursting or blow-out caused by the application of a sudden increased pressure on the duodenum while it is functionally closed at both ends by the pylorus and superior mesenteric artery; (4) a hydraulic type of blow-out, with gastric contents being propelled under pressure through an open pylorus and

striking the wall of the duodenum with great force. Of these four types, the third or "blow-out" type is probably the most common.

Roentgenologically the rupture may be identified by the presence of gas about the right kidney, extending to the paravertebral region and then upward along the crus of the diaphragm, or by the obliteration of the right kidney and psoas shadows associated with scoliosis of the spine due to retroperitoneal extravasation of duodenal juices. Occasionally the gas or fluid may extend to the left side of the abdomen and produce an outline of a kidney or cause obliteration of the normal structures on that side.

A case of rupture of the second part of the duodenum in a male as a result of a blow to the abdomen and right side of the chest is presented. Roentgenograms revealed gas surrounding the right kidney and right psoas muscle and in the retrocecal region.

One roentgenogram; 2 tables.

HOWARD L. STEINBACH, M.D.
University of California, S. F.

**The Use of Pro-Banthine and of Baridol in the Visualization of the Mucosal Pattern of the Small Intestine.** A. J. Glazebrook, C. Monegon, and E. Wong. Canad. M. A. J. **74:** 280–285, Feb. 15, 1956. (A. J. G., University of Manitoba, Winnipeg, Canada).

Demonstration of the mucosal pattern of the small intestine with ordinary suspensions of barium sulfate is hindered by the phenomena of flocculation and water absorption. To eliminate flocculation the authors have used Gastric Baridol, a colloidal liquid barium sulfate suspension stabilized by micropulverization. To minimize water absorption they decided to add the anticholinergic drug, Pro-Banthine. It was thought that by its inhibition of the parasympathetic this would reduce both segmentation and the activity of the villi. Although it would also temporarily inhibit peristalsis and thus slow the transit time, the net effect would be to reduce water absorption and thus aid in the maintenance of the fluidity of the barium meal.

Experiments were carried out on 11 healthy male medical students. In a first series all of the subjects received Baridol alone; in later examinations, Pro-Banthine was given together with the Baridol (either undiluted or diluted with water), with variations in the timing and dose. A few experiments were made with ordinary barium sulfate instead of Baridol.

It was found that the addition of Pro-Banthine tended to prevent congealing of the opaque medium into solid columns and thus revealed the mucosal pattern with more detailed clarity in greater lengths of intestine than Baridol alone. When the Baridol was diluted with water in a ratio of 7 oz. of Baridol to 5 oz. of water, an even better demonstration of the mucosal pattern was obtained than with undiluted Baridol and Pro-Banthine. The addition of Pro-Banthine to ordinary barium sulfate proved of little advantage.

Eight roentgenograms; 1 table.

JOHN P. FOTOPOULOS, M.D.
Hartford, Conn.

**Extraintestinal Roentgen Manifestations of Intestinal Lipodystrophy.** William R. Eyler and Howard P. Doub. J.A.M.A. **160:** 534–536, Feb. 18, 1956. (Henry Ford Hospital, Detroit 2, Mich.).

Intestinal lipodystrophy has some typical roentgen manifestations, although unfortunately the coarse mucosal pattern and flocculation or clumping, with discontinuity of the barium column, are not specific for this disease. The authors present 4 cases with extraintestinal findings as well as the typical "deficiency" pattern in the intestine. In 1 patient the duodenal loop was widened, due to a mass of retroperitoneal lymph nodes. In 1 case there was enlargement of the mediastinal lymph nodes, and in 2 changes occurred in the sacroiliac joints compatible with Marie-Strümpell arthritis. In 3 of these cases peripheral lymph nodes were palpable.

The authors suggest that, given a patient with a presumptive diagnosis of intestinal lipodystrophy, one should examine the chest and sacroiliac joints for possible additional manifestations of the disease, although they do not imply that these findings are any more specific than the intestinal roentgen studies.

Eight roentgenograms.

JOHN P. FOTOPOULOS, M.D.
Hartford, Conn.

**Granulomatous Reaction to Barium Sulfate In and About Appendix. Report of a Case.** Joseph Mendelhoff. Am. J. Clin. Path. **26:** 155–160, February 1956. (Department of Pathology, Emory University Hospital, Atlanta, Ga.).

A case is reported in which a patient with acute appendicitis underwent diagnostic roentgen studies with barium. An appendectomy was subsequently done, and a granulomatous reaction to the barium sulfate was found in and about the appendix.

In view of the initial symptoms of nausea, chill, fever, and episodes of gastric distress over a period of fifteen years, an acute exacerbation of chronic cholecystitis was first regarded as the most likely diagnosis. Roentgen studies of the gallbladder and upper gastrointestinal tract and intravenous pyelography disclosed no abnormalities. A barium enema study revealed a retrocecal appendix. It was concluded that the patient had probably had an attack of appendicitis, and appendectomy was performed forty-five days after the initial illness, forty-one days after the first gastrointestinal series, and thirty-one days after the barium enema.

It is presumed that the barium sulfate used in the diagnostic studies (either the upper gastrointestinal series or the barium enema) entered the appendix, escaping through a perforation into the mesoappendix and adjacent periappendiceal fat and resulting in a foreign-body granuloma. A surprising feature of the case, in view of the changes found, was the absence of symptoms between the time of initial improvement and elective appendectomy.

Two photomicrographs.

**Annular Pancreas in the Adult.** Gerald D. Dodd and Warren A. Nafis. Am. J. Roentgenol. **75:** 333–342, February 1956. (G. D. D., M.D. Anderson Hospital for Cancer Research, Houston 25, Texas).

In a review of the literature the authors found 104 cases of annular pancreas reported. To these they add 6, of which 5 were proved and 1 was diagnosed on the basis of characteristic roentgen findings. Three patients were symptomatic and 3 asymptomatic.

The mode of development of annular pancreas remains in dispute. Theories include simple regenerative hyperplasia of the gland following fetal peritonitis; failure of the tip of the ventral pancreatic

anlage to rotate completely to the right and posteriorly with the duodenum; and spread of the ventral pancreatic primordium about both sides of the duodenum prior to fusion. The result, regardless of the means, is a band of glandular tissue embracing the circumference of the duodenum.

Depending upon the degree of obstruction produced, an annulus may manifest itself at any time during life. The onset may be gradual or precipitous. Symptoms range from vague epigastric distress to severe epigastric pain, vomiting, and weight loss.

The diagnosis of symptomatic annular pancreas does not require a gastrointestinal series in the immediate postnatal period. An erect film will show the so-called "double-bubble sign" representative of air-fluid levels in the dilated stomach and duodenum. While not specific, this sign indicates duodenal obstruction and the need for immediate surgery.

In the adult, contrast studies are necessary to establish a diagnosis. Proximal to the annuius the usual signs of occlusion may be found, *i.e.*, dilatation, reverse peristalsis, and pyloric incompetency with or without gastric dilatation. The findings vary with the degree of obstruction. At the level of the annulus the duodenum is retracted toward the head of the pancreas by the encircling tissue. A large complete ring produces a symmetric constriction. Distally the duodenal diameter may be normal or diminished, depending on the degree and duration of obstruction.

Postbulbar ulceration and duodenal neoplasms present the major problems in differential diagnosis. The identification of a crater in postbulbar ulceration and the destruction of the mucosa by malignant tumors help to distinguish these conditions from annular pancreas.

Ten roentgenograms; 4 photographs.

FRANK T. MORAN, M.D.
Auburn, N. Y.

**Chronic Cholecystitis and Intramural Diverticulosis of the Gallbladder: Rokitansky-Aschoff Sinuses.** Charles E. Sherwood. Gastroenterology **30:** 310–315, February 1956. (260 Crittenden Blvd., Rochester, N. Y.)

Elective cholecystectomy was performed on a 55-year-old male patient who had experienced attacks of sharp, non-radiating substernal pain for one year. An oral cholecystogram had shown good concentration of the medium in a biloculate viscus. Around the distal segment of the gallbladder was a halo of small accumulations of contrast medium suggesting intramural mucosal diverticula (Rokitansky-Aschoff sinuses). No stones were identified. The surgical specimen was a thick-walled gallbladder with many adhesions. Microscopically, marked fibrosis and thickening of the muscularis and many Rokitansky-Aschoff sinuses were noted.

The author briefly reviews the 17 cases in the literature (including his own) in which Rokitansky-Aschoff sinuses were demonstrated roentgenographically. In 11 of these there was narrowing of some portion of the fundus or neck, with thickening of the wall distal to the constriction. In 8 of this number it was possible to discern, from the published illustrations, that the mucosal herniations were confined to the portion of the viscus distal to the narrowing. The author concludes that the relationship of the constriction to increased pressure within the distal segment of the gallbladder is undoubtedly a factor in chronic infection and in the production of diverticula. He also suggests that some of the deformities radiographically labeled as phrygian caps and hour-glass gallbladders may perhaps be of more clinical significance than has been heretofore throught.

Two roentgenograms; 2 photographs; 2 photomicrographs.

ARTHUR S. TUCKER, M.D.
Western Reserve University

**Cholografin Methylglucamine.** A. J. Glazebrook and Richard Hastings-James. Canad. M. A. J. **74:** 262–267, Feb. 15, 1956. (A. J. G., University of Manitoba, Winnipeg, Canada)

The essential agent in Cholografin Methylglucamine is the methylglucamine salt of N,N-adipyl-bis (3 amino-2,4,6 triiodobenzoic acid), and it is contained in a 52 per cent weight/volume solution. This preparation is equivalent to a 40 per cent solution of the sodium or lithium salt and is thus twice as concentrated as the 20 per cent sodium salt solution known as Cholografin. The mode of excretion and the technic of radiography are the same as with Cholografin 20 per cent. Chemically, the toxicity does not differ, but the necessity for a smaller quantity of the medium suggests that fewer reactions might be expected.

The authors report on 29 patients studied with this medium, 12 of whom had previously undergone cholecystectomy. The opacification was rarely as good as with Telepaque, but occasionally in a poorly functioning gallbladder Cholografin Methylglucamine gave superior definition. Also, additional information from visualization of the common bile duct was obtained. When oral preparations cannot be properly absorbed because of diarrhea or vomiting, the intravenous method is certainly more useful.

The authors obtained excellent visualization of the gallbladder and bile ducts with 20 c.c. of Cholografin Methylglucamine as compared with 40 c.c. of Cholografin. On the other hand, Cholografin Methylglucamine did not always give a better picture than ordinary Cholografin.

Twenty-two patients received 40 c.c. of Cholografin Methylglucamine, 1 was given 30 c.c. and the other 6 20 c.c. In 19 patients there were no side-effects. Three complained of feeling "tight" in the throat and had spells of coughing during the injection. It was felt that these effects were due to too rapid a rate of infusion and when this was slowed to 40 c.c. in six minutes they were not again observed. In 2 patients there was facial flushing, and 2 complained of slight nausea of momentary duration. One patient vomited after 20 c.c. had been given. Another experienced a sensation of distention in the right lower abdomen, and 1 had definite biliary colic. This last patient had stones both in the gallbladder and in the common duct.

The authors state that side-effects were more common with Cholografin Methylglucamine than with 20 per cent Cholografin. [Their table, however, lists a reaction in only 1 of the 8 patients receiving a 20-c.c. dose of the former preparation.—J. P. F.]

In summary, it is stated that Cholografin Methylglucamine represents an advance in intravenous cholangiography. The bulk of the injection may be reduced by half in most cases and better visualization of the gallbladder may sometimes be obtained. An in-

jection rate of more than 20 c.c. in three minutes should not be attempted.

Three roentgenograms; 1 table.

JOHN P. FOTOPOULOS, M.D.
Hartford, Conn.

**Roentgen Diagnosis of Spontaneous Internal Biliary Fistulas and Gallstone Ileus.** Herbert R. Zatzkin, Robert I. Tugendhaft, and Harold P. Curran. Surg., Gynec. & Obst. **102**: 234–238, February 1956. (Meadowbrook Hospital, East Meadow, L. I., N. Y.)

The authors present 20 cases of internal biliary fistula, of which 13 (65 per cent) were diagnosed prior to surgery. Ten cases were associated with gallstone ileus, and the diagnosis was made in 8.

The fistulas are the result of perforation of the gallbladder or common duct into the duodenum, colon, or stomach, by a gallstone or an inflammatory or neoplastic process. Perforated duodenal ulcers are responsible for most of the choledochoduodenal fistulas. Most of the patients in this series were females, obese and averaging seventy-two years of age. Clinically there is usually a history of biliary disease, with sudden relief of abdominal pain at the time of formation of the fistula. A majority of the patients have obstructive symptoms.

Radiographically the presence of gas in the biliary tree is generally accepted as evidence of a fistula. The calculi in gallstone ileus may be found anywhere in the abdomen; they vary in diameter from 2 to 6 cm. and may be only faintly calcified. About half of the patients had small bowel obstruction. The fistula may sometimes be demonstrated by either a gastrointestinal series or a barium enema.

In summary, the authors state that the diagnosis is suggested by intestinal obstruction in an obese female in the seventh or eighth decade, with a past history of gallbladder disease, roentgen demonstration of gas in the biliary passages and of the calculus itself anywhere in the abdomen.

Eleven roentgenograms; 2 photographs.

JAMES A. LYON, JR., M.D.
University of Pennsylvania

**The Use of Intravenous Cholangiocholecystography in the Diagnosis of Acute Conditions of the Abdomen.** Paul H. Jordan, Jr. Surg., Gynec. & Obst. **102**: 218–226, February 1956. (University of California Medical Center, Los Angeles, Calif.)

The author reports the results of 64 studies in 54 patients, receiving 40 c.c. of 20 per cent Cholografin intravenously. On the initial injection 6 patients had mild reactions, and of 10 patients receiving a second dose at a later date 2 showed mild reactions.

Thirty-three patients with acute abdominal conditions in whom the diagnosis of acute cholecystitis was entertained were studied. Demonstration of the common duct without visualization of the gallbladder was found to be strongly suggestive of cholecystic disease. In only 1 patient of 22 with proved cholecystic disease was the gallbladder visualized. In 11 patients in this group who were later proved not to have biliary disease both the common duct and the gallbladder were demonstrated. In 210 cases of proved cholecystic disease and in 4 of pancreatitis, no visualization of any sort was found. Nine of the patients without visualization of the extrahepatic system showed evidence of liver dysfunction on chemical study. In the patients with cholecystic disease, visualization of the common duct was obtained in 100 per cent of those studied within twenty-four hours, but in only 25 per cent of those studied more than twenty-four hours after the onset of their illness. The author suggests that this may be due to secondary hepatic dysfunction.

In 22 cases of non-acute disease studied, visualization with oral Priodax and intravenous Cholografin were compared. In 8 of 14 patients with non-visualization by the oral medium, parts of the biliary tract were demonstrated with Cholografin. Of these 6 were found to have cholecystic disease at operation. Of the other 2 patients, 1 had had a sphincterotomy and the other a vagotomy, and it was felt that the loss of tone in the sphincter of Oddi allowed bile to drain too rapidly into the duodenum for the oral medium to become concentrated by the gallbladder.

In a number of cases liver function studies were performed on patients submitted to study with Cholografin and it was found that visualization did not occur if the BSP retention in forty-five minutes (injection of 5 mg. per kg.) was over 15 per cent or if the serum bilirubin was over 3.0 mg. per cent. In 6 of 7 patients with non-visualization in whom the study was later repeated successful visualization was obtained.

Disadvantages of intravenous Cholografin, in addition to the occurrence of reactions, are the inability to assess the concentrating power of the gallbladder and the inadequate visualization of the terminal portion of the common duct due to overlying duodenum. To previously reported indications for its use, the author adds the differential diagnosis of acute abdominal conditions.

Two roentgenograms; 6 tables.

LESLIE M. ZATZ, M.D.
University of Pennsylvania

**Percutaneous Transhepatic Cholangiography.** Henry A. Kidd. Arch. Surg. **72**: 262–268, February 1956. (London, England)

Percutaneous transhepatic cholangiography is a valuable diagnostic aid in obstructions of the common bile duct. A needle 15 cm. long is inserted below the right costal margin and directed into the liver while the patient takes shallow breaths. Frequent aspirations are made until bile is obtained. Cultures and pressure measurements can then be taken. About 30 c.c. of bile are aspirated and replaced by 18 c.c. of 50 per cent iodopyracet (Diodone). Anteroposterior and lateral roentgenograms are then made.

No complications were noted from hemorrhage or puncture of the small or large intestine in the 6 patients examined. The chief danger is puncture of the gallbladder and subsequent bile peritonitis. To prevent this, 5 c.c. of iodopyracet are injected if bile is aspirated after the needle has been inserted only a short distance. If the needle is in the gallbladder, it is pushed on through the hepatic surface of that organ, where it will probably enter a main duct, cholangiography is completed, and cholecystectomy must be performed during the next few hours. One erroneous diagnosis resulted from failure to aspirate enough bile and consequent incomplete filling of the biliary system.

Seventeen roentgenograms; 3 drawings.

RICHARD E. BUENGER M.D.
Chicago Ill.

## THE MUSCULOSKELETAL SYSTEM

**Benign Conditions Simulating Bone Tumors.** Vincent P. Collins and Lois C. Collins. J.A.M.A. **160:** 431–436, Feb. 11, 1956. (V. P. C., 1200 M. D. Anderson Blvd., Houston 25, Texas)

The authors state that malignant bone tumors are sometimes suspected from the roentgenogram when the findings are due actually to only a normal variation, a developmental abnormality, a traumatic lesion, a metabolic, infectious or inflammatory change, or a benign tumor.

Normal features which may suggest a neoplastic process include: the linea aspera of the femur, the site of attachment of interosseous membranes on the tibia and fibula or radius and ulna, the double cortical contour sometimes observed in infants of four to eight months, and a roughened or irregular appearance of the posterior aspect of the lower femur. In such cases comparison with the opposite side or repeated examination should establish the benign nature of the condition.

Developmental abnormalities which may present problems in differentiation are cortical defects, nonosteogenic fibroma, fibrous dysplasia, and osteochondritis in an unusual site. Biopsy may be required to rule out a malignant lesion in such cases.

Occult trauma, fractures resulting from relatively minor or forgotten injuries, and periosteal bruises may all produce an appearance simulating a tumor. Myositis ossificans, a sequel of periosteal and muscle trauma, is a matter of particular concern. In its early stages, it may lead to erosion and demineralization of bone beneath a subperiosteal hemorrhage associated with a tender soft-tissue mass. Here the danger of error is not ended with biopsy, which may reveal bizarre giant cells, active osteoblasts and osteoclasts, and spindle-shaped fibroblasts, further strengthening a clinical impression of osteosarcoma. Occasionally only detailed study after amputation and observation of the subsequent clinical course will establish the diagnosis.

Rarely eosinophilic granuloma or the cholesterol histiocytosis of Hand-Schüller-Christian will occur as a solitary lesion requiring biopsy. In Gaucher's disease there is a symmetrical distribution of radiolucent lesions expanding the tubular shafts of the ends of long bones, and contralateral comparison will readily explain a local pathological fracture or aseptic necrosis. Other metabolic disturbances susceptible of misinterpretation are Letterer-Siwe's disease, scurvy, hyperparathyroidism, and osteitis deformans. Solitary or diffuse osteolytic lesions may suggest metastatic involvement, but skeletal surveys and proper blood chemistry studies reveal the role of the over-active parathyroids.

A careful history, skeletal surveys, serological examination, and a complete clinical evaluation are often necessary for the differentiation of pyogenic osteomyelitis, syphilitic osteitis and the varied mycotic infections.

Cortical hyperostosis in the infant is marked by periosteal elevation, pain and swelling. A skeletal survey with particular attention to the mandible will often preclude the necessity of biopsy in this rare inflammatory reaction. The osteosclerotic rim around a radiolucent center is classed as an inflammatory reaction by the authors because of the spreading rim of sclerosis which increases the resemblance of osteoid osteoma to osteosarcoma. The bone changes in osteitis pubis and in hypertrophic pulmonary osteoarthropathy are usually associated with sufficiently clear syndromes to make their origin clear.

The three benign tumors most likely to be mistaken for malignant bone tumors are the giant-cell tumor, periosteal chondroma, and chondroblastoma. Biopsy is usually necessary for diagnosis unless there is opportunity for follow-up study over an interval of time.

Seven illustrative case reports are included.

Seven roentgenograms. SAUL SCHEFF, M.D.
Boston, Mass.

**Primary Reticulo-Sarcoma of Bone.** H. A. Magnus and H. L.-C. Wood. J. Bone & Joint Surg. **38-B:** 258–278, February 1956. (King's College Hospital, London, England)

The authors report 7 cases of primary reticulosarcoma of bone (synonymous with reticulum-cell sarcoma) and consider the relationship between that tumor and Ewing's sarcoma. They note that, although in the American literature the two are usually regarded as distinct entities, there has been a tendency in recent years to stress the difficulty of separating them.

In Ewing's tumor the main features are said to be the youth of the patient, the rather characteristic radiographic picture, the radiosensitivity of the lesion, the very bad prognosis, and the uniform histologic appearance. Reticulosarcoma occurs in an older age group, the prognosis is relatively good, and the histologic picture is pleomorphic.

The radiologic features are extremely variable in Ewing's tumor, including lysis, mottling, sclerosis, cyst formation, and periosteal reaction. Typically, reticulosarcoma is situated near the end of a long bone but extends towards the shaft. The cortex is destroyed, but there is no expansion. Reactive new bone under the periosteum is not a constant feature, and if a soft-tissue component be present it is never calcified. In responding to irradiation the repaired bone assumes a density somewhat greater than that of normal bone. This is in contrast to Ewing's tumor, where the post-irradiation bone is normal in appearance.

The authors' 7 cases illustrate a diversity of radiologic changes which did not conform to any one type. Three of the tumors were in long bones (tibia, femur, and fibula), and 4 in short bones (vertebrae, right acromion, and sternum). When histologic changes were considered together with the radiological features, distinction was found even more difficult.

After examining the literature on Ewing's sarcoma and reticulosarcoma, the authors reach the conclusion that the separation of these two tumors is an artificial one. They further believe that their 7 cases confirm this observation.

[These conclusions are certainly open to question in this highly debatable subject. The pathologists at the abstracter's institution firmly believe that these two entities can be separated histologically, although clinical and x-ray findings will overlap.—C. M. G.]

Seventeen roentgenograms; 10 photomicrographs; 6 photographs (5 in color); 2 tables.

C. M. GREENWALD, M.D.
Cleveland Clinic

**The Roentgenographic Appearances of Osteoid Osteoma in Children.** Folke Knutsson. Acta radiol. **45:** 125–128, February 1956. (Roentgen Department, University Hospital, Upsala, Sweden)

In a case of osteoid osteoma involving both femora of

a five-year-old girl, the periosteal reaction (in the right femur) in the initial stage was extremely marked, embracing the entire circumference of the bone and dominating the roentgen picture much more than in the adult. There were subsequent thickening and sclerosis of the cortex of the femur, however, with eventual development of the typical eccentric appearance. On the left side a characteristic nidus with local periosteal reaction and sclerosis was present.

The author wishes to draw attention to the fact that brisk periosteal activity is probably to be expected in osteoid osteoma in a younger patient.

Seven roentgenograms. P. O'BRIEN, M.D.
Bowman Gray School of Medicine

**Aneurysmal Bone Cyst.** Roland Barnes. J. Bone & Joint Surg. **38-B:** 301–311, February 1956. (University of Glasgow, Glasgow, Scotland)

Aneurysmal bone cyst is a benign lesion of bone that consists essentially of fibrous tissue, honeycombed by vascular spaces. It causes localized distention and destruction of the affected bone, limited peripherally by a thin bony shell.

Most of the patients are children, adolescents, or young adults. There is a preference for the vertebral column and the shafts of long bones. The neural arch is involved more often than the body of the vertebra. In the long bones the cyst is usually situated beneath the periosteum of the shaft and rarely invades the epiphysis. Aneurysmal bone cysts have also been described in most of the flat bones, the skull, and bones of the hands and feet. Contiguous bones are often affected, especially in lesions of the spine.

On roentgenograms the lesion in a long bone appears as a cyst arising from the cortex of the shaft, limited peripherally by a thin shell of subperiosteal bone. There is usually some destruction of the underlying cortex, but the cyst does not as a rule invade the medulla, and only rarely is there uniform expansion of the affected bone. The cyst frequently has a mottled or trabeculated appearance, and there may be irregular strands of ossification, which are sometimes a feature of older lesions. In the spine the picture is often obscure, because it may be difficult to demonstrate the bony shell, and the osteolytic process is then likely to be attributed to a primary or metastatic tumor.

The remarkable feature of an aneurysmal bone cyst is the tendency to heal after incomplete removal or even without treatment, which suggests that it may not be a tumor. The lesion should be treated by excision or curettage as soon as possible. Cysts in the long bones can usually be excised completely, but curettage is the only method for lesions of the neural arch or of the spinous and transverse processes. Radiotherapy has given completely satisfactory results but it has the disadvantage of not providing histological confirmation of the diagnosis.

Five cases of aneurysmal bone cyst are presented.

Seven roentgenograms; 3 drawings (1 in color); 3 photomicrographs, in color; 1 table.

HOWARD L. STEINBACH, M.D.
University of California, S. F.

**Aneurysmal Bone Cyst. A Report of Three Cases.** F. W. Taylor. J. Bone & Joint Surg. **38-B:** 293–300, February 1956. (Sheffield, England)

Three cases of aneurysmal bone cyst are reported.

*Case I:* A 16-year-old girl had slight limitation of flexion of the lumbar spine. Radiographic examination demonstrated a lesion involving the third lumbar spinous process, which had lost its normal contours and was expanded to about two or three times its normal size. The process appeared to be limited peripherally by only a thin shell of bone. The mass was removed and the patient became free of symptoms.

*Case II:* A 13-year-old girl complained of aching of the left elbow for seven weeks. Radiographs showed a small cystic lesion in the lower end of the humerus, which increased rapidly in size. A biopsy was performed, after which the lesion recalcified to some extent. A course of roentgen therapy was followed by relief of symptoms.

*Case III:* A 4-year-old girl experienced pain in the neck for about three months, with some limitation of movement of the head. Roentgenograms revealed a cystic expansion of the spinous process of the atlas, outlined by what appeared to be a thin shell of bone. On subsequent observation, the lesion was shown to have increased in size, and roentgen therapy was instituted. This was followed by a gradual decrease in discomfort and the child regained full range of movement in the neck. Roentgenograms obtained two weeks after x-ray therapy showed an apparent increase in the size of the cyst, but this was followed by a gradual loss of the cystic appearance, and the spinous process, though larger, has remained well calcified.

The author believes that the lesion described here is a type of cavernous hemangioma and suggests the term "hemangiomatous bone cyst" as preferable to "aneurysmal bone cyst." A survey of the published cases suggests that in an early state these cysts are amenable to local surgery, which is the treatment of choice, but for inaccessible lesions deep x-ray therapy may be effective.

Twelve roentgenograms; 1 photograph; 4 photomicrographs. HOWARD L. STEINBACH, M.D.
University of California, S. F.

**Dysplasia Epiphysialis Punctata.** Jean M. Sheach and J. H. Middlemiss. Brit. J. Radiol. **29:** 111–113, February 1956. (Department of Radiology, United Bristol Hospitals, Bristol, England)

Punctate epiphyseal dysplasia is a rare congenital disorder, presenting usually at birth or in early infancy and affecting mainly cartilage, muscle and the eyes. No record of a patient reaching adult life could be found in the literature. The chief clinical features are: (*a*) flexion deformity of the limbs due to muscle fibrosis, commonly at the knees and elbows; (*b*) dwarfism; (*c*) changes in skin temperature; (*d*) bilateral cataract; (*e*) dullness of intellect.

The case of a male infant first seen at twenty-five days is presented. The initial radiographic findings were as follows:

(1) All the epiphyses at the ends of the long bones were abnormal in appearance, consisting of irregular multicentric ossification points, extending beyond the normal confines of ossific centers of this age.

(2) The patellae and acetabula were similarly affected, but not the short bones of hands and feet, except for short first metacarpals.

(3) The shafts of both humeri and both femora were short, and there were wide extremities to these bones. The shafts and metaphyses of all the other long bones were normal.

(4) The posterior ends of the ribs showed multicentric ossification points.

(5) A vertical split was present through the middle of certain of the vertebral bodies.

(6) There was linear vertical calcification in the midline at the symphysis pubis.

(7) No ossific abnormality was present in the skull.

At eight months the child weighed only 6 pounds 12 ounces; the roentgen findings were unchanged and there was no evidence of fusion of the ossification points. Death occurred at nine months.

Histologic examination of the long bones revealed delayed differentiation of the terminal articular surfaces, myxoid degeneration of the epiphyseal cartilage with cystic change, fibroblastic colonization of the myxoid areas, absence of secondary ossification centers indicating retardation of bone age, and some changes of endochondral and periosteal bone growth, with areas of woven bone.

It is of interest, in view of the fact that a familial tendency has occasionally been reported, that a sibling had died at eight days of age with gross deformity of both elbows and shortening of the humeri (no further data available).

Five roentgenograms, 2 photographs.

C. M. GREENWALD, M.D.
Cleveland Clinic

**Dysplasia Epiphysialis Hemimelica (Tarso-epiphysial Aclasis).** T. J. Fairbank. J. Bone & Joint Surg. **38-B:** 237–257, February 1956. (Cambridge, England)

Dysplasia epiphysialis hemimelica is a rare epiphyseal dysplasia, which was initially described under the title tarso-epiphyseal aclasis. The author considers this latter name unsatisfactory for two reasons: first, because the tarsus, although it is the most common site, is not constantly involved; second, because the condition is not an "aclasis" but a true dysplasia or faulty growth of part of the epiphysis itself. There are only two other conditions known in which the primary defect lies in the epiphysis: dysplasia epiphysialis multiplex and dysplasia epiphysialis punctata.

This report is based on a total of 27 recorded cases, including 14 which the author has collected from British orthopedic centers. Characteristically the epiphyseal abnormalities are confined to one side of the affected limb; the medial side was involved in 19 and the lateral in 8 cases. In no instance was more than one limb affected. The lower femoral epiphysis and talus are the most common sites. With a few exceptions, changes at the knee were accompanied by changes at the ankle or in the tarsus. Males predominate. The youngest subject was six months old at the time of diagnosis, the oldest twenty-three years. The majority were first seen between the ages of two and eight. The most common complaint is an increasing swelling of bony consistency over the inner or outer aspect of the knee or ankle.

The x-ray findings are diagnostic. There may be generalized though irregular enlargement of the affected side, or more commonly there can be seen a number of separate centers of ossification, irregular in shape and size, discrete from the main epiphysis and often so closely packed together that they appear to form a single mass of bone. If the projecting mass impinges on the opposing articular surface, varus and valgus deformity is produced, but large masses may project from the side and margin of the epiphysis without causing any angular deformity. The metaphysis in general is unaffected. When the tarsus is involved, there may be massive enlargement of the body of the talus, but even here one side is more severely affected than the other.

Swelling gradually increases for the first few years of life. After the age six or seven there may be little deterioration. New centers of ossification may appear, and the multiple bony centers tend to fuse into a common mass which usually fuses with the rest of the epiphysis.

Part or all of the outgrowth has been removed in a number of patients, with benefit in every case. Where there has been varus or valgus deformity from the pressure of the outgrowth, this was improved or completely corrected. Microscopically the appearance is like that of an osteochondroma, and there is no feature upon which to base a biopsy diagnosis.

The cause of this condition is unknown but, whatever it may be, it is active early in the fifth week of fetal development. It affects either the pre-axial or post-axial part of the apical cap of a single limb bud, probably for a very short time and in a minute area, and the localization of the future lesion depends on the exact timing and site of this fault.

Fourteen case reports are presented, together with radiographs. Two of the lesions were in the upper limb.

Forty-three roentgenograms; 4 photomicrographs; 1 photograph; 1 drawing in color; 1 table.

C. M. GREENWALD, M.D.
Cleveland Clinic

**Infantile Cortical Hyperostosis. Report of Seventeen Cases.** Glen G. Cayler and Carrell A. Peterson. J. Dis. Child. **91:** 119–125, February 1956. (Children's Hospital of the East Bay, Oakland, Calif.)

Seventeen cases of infantile cortical hyperostosis seen during a period of six and a half years are reported. The incidence of involvement of the various bones was as follows: mandible, 76 per cent; humerus, 35 per cent; ulna, 35 per cent; clavicle, 30 per cent; ribs 30 per cent; radius, 24 per cent; tibia, 24 per cent; femur, 18 per cent; scapula, 18 per cent; fibula, 18 per cent. Since the mandible is so frequently involved, this condition should be thought of in the presence of any firm, tender swelling of the face during the first six months of life.

In this series clinical swelling was invariably accompanied by roentgen changes. Subperiosteal new bone formation, while not specific, is highly suggestive in the mandible of a young infant. Oblique lateral views were found of importance in demonstrating minimal mandibular changes.

Infantile cortical hyperostosis may be confused with a great variety of diseases. In the present series initial clinical diagnoses were: parotitis, syphilis, fracture, brachial plexus injuries, cellulitis, paralysis of the arm, trauma, sickle-cell disease, tuberculosis, and tumor.

Three roentgenograms; 1 photograph.

J. E. CARLISLE, M.D.
Shreveport, La.

**Engelmann's Disease.** D. Ll. Griffiths. J. Bone & Joint Surg. **38-B:** 312–326, February 1956. (Manchester, England)

Engelmann's disease is probably less rare than has

been thought. Sixteen of the 22 cases accepted by the author have come to light in the last twelve years. The syndrome consists usually of physical underdevelopment, an abnormal gait, and a series of symmetrical hyperplastic changes affecting the shafts of the major long bones and, usually, the base of the skull. The hyperostosis appears to be progressive and ultimately may become widespread. The sex incidence is approximately equal. The earliest age at which the diagnosis has been made is thirty-three months and the latest fifty-five years.

Fifteen of the reported cases occurred before the age of fifteen. With one exception, the children had walked rather late, and dentition had tended to be retarded. In all who were old enough, puberty had been late, the genitalia were never very large, and secondary sex characteristics were seldom well developed.

Symptoms always appeared early in life, usually before the age of seven and often as soon as walking started. Failure to thrive and to gain weight in early childhood was a frequent presenting symptom, as were easy fatigue and the abnormal gait. All but 7 patients complained of pain.

Only one patient was said to be tall. Five were well below average height. The limbs, especially the legs, tended to appear long and slender in proportion to the height. The general physique was considered poor in all but 2 cases. Muscular weakness and underdevelopment were reported in all fully described cases except 3.

The bony lesions are restricted to the diaphyses in the long bones, and usually to the middle two-fourths of these. Involvement of any metaphysis or epiphysis has not previously been recorded. All the bony changes have been strictly symmetrical, with the exception of a single case in which one fibula was unaffected. Thickening of the vault or base of the skull was encountered in all except 8 cases.

A typical case of the disease in a 29-year-old woman is presented here. Physical and sexual development were delayed. Roentgenograms demonstrated an irregular but symmetrical increase in density of the base of the skull. The long bones showed a remarkable symmetrical sclerosis of their diaphyses. Subperiosteal and particularly endosteal deposition of new bone of amorphous appearance produced much cortical thickening. The epiphyses were normal, and the metaphyses were clear in all bones except the humeri and the femora. The patient had complained of pain since early childhood and at the time of this report it was continuous and widespread.

Fifteen roentgenograms; 1 drawing; 2 photographs; 3 photomicrographs, in color; 1 table.

HOWARD L. STEINBACH, M.D.
University of California, S. F.

**The Value of Knowing the Direction and Nature of the Force Causing a Fracture.** George Perkins. J. Bone & Joint Surg. **38-B:** 227–236, February 1956. (St. Thomas's Hospital, London, England)

Knowledge of the direction and nature of the force causing fracture is of value for two reasons. From it one can deduce the degree of damage to the soft parts and infer a logical method of reduction of the fracture.

Radiographs almost always reveal the direction of force producing the fracture. The shattering effect of a high velocity missile is rarely seen except during war. In civilian life the possible forces are longitudinal compression, angulation, shearing, transverse compression, and rotation. Longitudinal compression occurs with falls from heights and causes either several linear cracks without displacement or a T-fracture into a joint. Angular forces produce a transverse fracture of the shaft of a bone. The presence of a separate triangular fragment indicates that the bone was bent until it broke, the fragment being on the inside of the bend. A shearing force is one that strikes the shaft at right angles over a limited area, with continued momentum. A similar force with dying momentum, causing a clean transverse fracture, may be called a tapping force. Transverse compression occurs when a limb is crushed. Rotation causes a spiral fracture.

Information as to the nature of the fracturing force may also be obtained from the history, which is important but may be equivocal, and from the nature of the skin damage. The damage sustained by soft parts often controls treatment. In a crush injury, tissue may be devitalized and a wound-toilet operation is often desirable. Postponement of plating is advisable.

Pott's fracture is used by the author to illustrate the usefulness of knowing how a bone has been broken. This term is used to cover any fracture of the leg bones involving the ankle joint, the cases being divided according to the direction of the fracturing force. Lateral rotation causes fracture through the lateral malleolus. The medial malleolus may or may not be broken. Abduction fracture is not as common as lateral rotation but more important because it is more likely to leave the ankle crippled. In the anteroposterior view there is a transverse fracture of the fibula about 2 inches up. An adduction force on the foot causes a sprain of the subtalar joint, and if this is continued, the tibia breaks at its junction with the medial malleolus. The tip of the lateral malleolus is usually avulsed. The shear fracture is not common, and both malleoli break transversely at the level of the horizontal part of the mortise. Vertical fracture is caused by longitudinal compression, the usual history being fall from a height.

Twenty-eight roentgenograms; 5 photographs.

C. M. GREENWALD, M.D.
Cleveland Clinic

**Lumbar and Sacral Compression Radiculitis (Herniated Lumbar Disk Syndrome).** Donald Munro. New England J. Med. **254:** 243–252, Feb. 9, 1956. (Boston University School of Medicine, Boston, Mass.)

The author discusses the clinical aspects of the problem of herniated lumbar disk syndrome in a total of 545 patients admitted to the Neurological Service of the Boston City Hospital in the seventeen years between 1937 and 1955. Of these patients, 356 underwent a total of 375 operations and 189 were treated conservatively.

The usual history was one of trauma—slight to severe—followed by a succession of minor back injuries which increased the root irritation and the resulting symptomatology. This was true of both industrial and non-industrial patients, 66 per cent of both groups being hospitalized within two years of the primary trauma.

The procedure *par excellence* in making the diagnosis of disk herniation is myelography. The medium of choice is Pantopaque, because of its relative safety, freedom from complications, and the high percentage of readable films. No medium has proved infallible and even with Pantopaque the error in the readable films is

13 per cent. The clinical diagnosis is at best unreliable, since 20 per cent of patients without a disk rupture showed the same signs and symptoms as patients with a rupture at the fourth and fifth lumbar interspaces.

Prior to operation, every effort should be made, preferably during hospitalization, to rule out spondylolisthesis, pseudarthrosis of the spinous processes, herniation through the lumbar fascia, tuberculosis, pes planus and bad posture, tumors, and congenital defects. A well organized plan of conservative therapy should be given a fair trial before surgery is undertaken.

Operation must be carried out with a view to decompression of the intra- or extradural root or of the cauda. The three most important steps are proper exposure, even to the sacrificing of a pair of articular facets; "super-hemostasis" to avoid the compressing effects of organized, infected, or scarified hematomas; and probing of the involved nerve roots.

In the 375 operations, 209 single protruding disks were found at either the fourth or fifth lumbar interspace, with compression of the associated nerve root or cauda equina. In the 166 remaining cases the findings included rupture of one or more other disks (21 cases); no rupture of any disk (24 cases); compression of the root by a tight dural sheath (13 cases), by the scar of a previous operation (26 cases), by previous fusion (5 cases) or by a tight bony root canal (16 cases); compression of the cauda equina by a narrowed spinal canal (18 cases); numerous other less frequent conditions from overlapping spinous processes with pseudoarthroses in 4 patients to meningioma in a single instance.

The author is strongly opposed to spinal fusion at the time of exploration. If indicated, this can be done electively at a later date. A detailed description of the necessarily meticulous postoperative regime is outlined.

Four patients in this series died in the near postoperative period. Of the 2 that came to necropsy, 1 died of a kidney shut-down following a prophylactic transfusion with mismatched blood and the second of miliary tuberculosis. Of the 2 deaths not verified by autopsy, was attributed to a fulminating streptococcus infection and the second, in a seventy-three-year-old man, to circulatory disease culminating in a severe gastrointestinal hemorrhage.

Eleven roentgenograms.

SAUL SCHEFF, M.D.
Boston, Mass.

**Osteomyelitis of the Vertebrae as the Result of Infection of the Urinary Tract.** Stanley W. Henson, Jr., and Mark B. Coventry. Surg., Gynec. & Obst. **102:** 207–214, February 1956. (Mayo Clinic and Mayo Foundation, Rochester, Minn.)

The importance of the urinary tract as a primary source of infection in vertebral osteomyelitis is emphasized by the authors. When the offending organism is one commonly found in the urinary tract and there is a history of previous or intermittent pyuria, it is likely that this system is the primary seat of disease. The vertebral veins are the most probable route of spread to the spine and, although a genitourinary surgical procedure or other manipulation is the usual precipitating factor, this is not essential for the development of bacteremia and subsequent vertebral osteomyelitis.

Roentgen changes indicative of vertebral involvement may be quite delayed; the authors advocate serial roentgenograms in any case where the initial examination is negative and the symptoms are not well explained. The picture is one of intervertebral disk narrowing, with rarefaction of adjacent bone and loss of trabecular detail, followed by varying degrees of collapse. Tuberculous spondylitis is differentiated by its chronic course and the absence of prominent reactive bone change and eventual bony bridging seen in pyogenic lesions on the roentgenograms. When roentgen changes are present, needle biopsy is recommended to obtain a bacteriologic diagnosis so that early and specific antibiotic therapy can be started. Occasionally an open biopsy may be more satisfactory.

Seven cases of vertebral osteomyelitis from primary urinary tract infection are tabulated. The organism was identified following needle biopsy in 5 patients; characteristic urinary system bacteria were recovered from urine and blood cultures in the remaining 2. Although all the patients gave a past or present history of urinary infection, 3 of the group had not undergone surgery or manipulation prior to the spinal disease.

Eight roentgenograms; 3 tables.

LAWRENCE A. POST, M.D.
University of Pennsylvania

**Rheumatoid Spondylitis in a Prepubertal Female.** T. N. Lynn. J. Dis. Child. **91:** 158–161, February 1956. (Barnes Hospital, St. Louis, Mo.)

Rheumatoid spondylitis is generally considered to be a disease of young adult males. The author presents what he believes is the second recorded case in a prepubescent female. [The first was presumably that mentioned by Polley and Slocumb in their review (Ann. Int. Med. **26:** 240, 1947. Abst. in Radiology **50:** 134, 1948).]

Symptoms were pain and stiffness in the mid-back with flexion deformity over a period of two years. Roentgenograms of the spine revealed a "C" type kyphosis, moderate osteoporosis, and squaring of L-4. Pelvic films showed sclerosis and narrowing of the sacroiliac joint.

The earliest radiological findings in rheumatoid spondylitis are observed in the sacroiliac joints, consisting in marginal decalcification followed by osteosclerosis and loss of joint space. The apophyseal joint findings are similar. The vertebral bodies show squaring of the anterior borders, with pointing of the corners due to calcification of the anterior longitudinal ligament, with ultimate bridging between the vertebrae and bamboo spine.

In the case reported, roentgen therapy (150 r per week for four weeks) was effective in relieving the pain.

Two roentgenograms; 2 photographs.

J. E. CARLISLE, M.D.
Shreveport, La.

**Fractures of the External Humeral Condyle.** Henry Milch., J.A.M.A. **160:** 641–646, Feb. 25, 1956. (225 W. 86th St., New York 24, N. Y.)

The author condemns as completely erroneous the classification of the elbow as a typical ginglymus joint. On the contrary, it is highly complicated and in many respects homologous with the knee joint. Excluding the trochoid superior ulnar joint, it consists of two components: (1) the ginglymotrochoid condyloradial joint, allowing flexion, extension and rotation, and (2) the ginglymotrochleoulnar joint, permitting flexion, extension, and a helical radial rotation toward the thumb side of the hand.

The head of the radius is markedly higher on the medial side, forming a sort of ridge which fits snugly against the lateral surface of the trochlea as it completes its excursions in the condylotrochlear sulcus or groove. Further, there is a ridge of elevated bone which runs between the condyle and olecranon of the ulnar sigmoid notch which fits tightly into the trochlear groove of the humerus. These two ridges are of importance in preventing lateral dislocations of the elbow. This stability, however, is not achieved without some attendant risk. Locked as they are in their respective depressions, the ridges act as perfect wedges in the event that force is directed axially along either the radius or the ulna.

Fractures of the external humeral condyle are of two types. The first, uncomplicated fracture of the external condyle, may involve only the capitellum or may include a part of the trochlear surface, but the fracture line must lie lateral to the trochlear groove so that there is preservation of the trochleo-ulnar joint, preventing dislocation of the ulna. In the second type the fracture line extends to or medial to the trochlear groove, thus permitting outward rotation of the ulna so that its coronoid surface comes to articulate with the lateral or fractured surface of the trochlea instead of the normally articulating inferior surface. It is this dislocation of the ulnar articulating surface with the trochlea which is characteristic of this second type of fracture and determines the therapy.

The radiological distinction between the two types of fractures is of great importance since in the acute Type I fracture closed reduction in the absence of displacement is usually successful. In Type II, where the fracture line extends to, or medial to, the trochlear groove, open reduction is essential to correct the ulnar dislocation and to maintain this correction.

Six roentgenograms; 1 photograph; 1 drawing.

SAUL SCHEFF, M.D.
Boston, Mass.

**Fatigue Infraction of the Middle of the Tibia in Ballet Dancers.** H. Jackson Burrows. J. Bone & Joint Surg. **38-B:** 83–94, February 1956. (St. Bartholomew's Hospital, London, England)

The author reports an unusual defect seen in the shins of 4 young healthy ballet dancers. The lesion was at about the middle of the tibial crest and was associated with local tenderness and a palpable lump. Pain preceded the objective findings, being present primarily at the take-off in leaps.

The chief radiological feature was a small horizontal fissure extending into the cortex of the tibial crest, which was itself thickened by subperiosteal new bone with a slightly irregular surface. This picture of a fissure with adjacent hyperostosis is very similar to Looser's *Umbauzonen* in the osteomalacias, and to other pseudofractures. Biopsy performed in 2 of the 4 cases revealed no evidence of general disease, but there was a complete absence of callus in the defects.

The occupational incidence along with the good health of the patients pointed to fatigue or stress as the cause of the defect, and the author concludes that it represents a fatigue fracture—or more precisely fatigue infraction, since only part of the diameter of the bone is involved. Fatigue fractures of the tibia commonly occur in the upper third and are exceptional at the level involved in these cases. The relation of stress to the site of the lesion is discussed. Of interest was the fact that 3 of the 4 patients were males, though women greatly outnumber men as ballet dancers.

The failure of these infractions in normal bones to display the abundant callus and ready union of ordinary fatigue fractures may be attributed to continuance of the distracting forces and, perhaps more important, the virtual absence of play between the surfaces of the infraction. Completion of the fracture leads to prompt union. When the diagnosis seems reasonably certain, the best treatment may be immobilization in a long walking plaster.

A fifth case is included to illustrate the occurrence of spontaneous fracture complicating a probable fatigue infraction. A male dancer who had complained of mid-tibial pain and a tender swelling at the mid-tibial crest suddenly felt and heard "a colossal crack" in that area just as he leapt. Roentgenograms revealed a comminuted fracture.

Twenty-three roentgenograms; 4 photomicrographs; 1 radiomicrograph.

C. M. GREENWALD, M.D.
Cleveland Clinic

**Sudeck's Atrophy in the Hand.** L. W. Plewes. J. Bone & Joint Surg. **38-B:** 195–203, February 1956. (Luton and Dunstable Hospital, Luton, England)

Sudeck's atrophy of the acute type is not uncommon in the hand. The author reports a series of cases in 37 patients, two-thirds of whom were women. The average age was fifty-eight years, with a range of thirty-three to seventy six. The causative factor was most frequently an injury in the region of the wrist, particularly a Colles' fracture.

The symptoms of pain, swelling and dysfunction developed at an average of eight weeks after injury and were accompanied by the following signs: hyperemia, loss of Lange's lines, obliteration of skin creases, loss of tissue turgor in the pulp, changes in skin temperature and color, nail ridges, limitation of movement, and tenderness. Power of grip was grossly impaired, averaging 10 per cent of normal, and the volume of the hand was increased by 10 to 20 per cent.

X-ray changes were not present initially, appearing some six to eight weeks after onset of symptoms. By that time the clinical signs and symptoms might have disappeared. There was characteristic spotty rarefaction involving the ends of the phalanges and metacarpals. Sometimes the carpus and distal ends of the radius and ulna were involved, whereas the shafts of the bones were only slightly affected. This spotty appearance is quite unlike the generalized ground-glass appearance seen in disuse atrophy, which takes a much longer time to develop. It is true that slight radiographic changes can sometimes be seen after injury without the signs and symptoms of Sudeck's syndrome. Recent analysis of a group of wrist fractures showed slight subchondral spotty osteoporosis on films taken eight weeks after removal of the cast in a small percentage of the cases. Well marked radiographic changes were always accompanied by signs and symptoms of Sudeck's atrophy.

Much has been written about management of this condition, particularly in relation to surgical attacks on the sympathetic system, parasympathetic stimulation, the application of plaster splints, x-ray therapy, physical therapy, and more recently use of vasomotor relaxants and cortisone. Treatment in the author's clinic was conservative, and proved effective if initiated within six weeks of symptoms. This treatment

consisted in the application of heat, elevation of the limb, and graded function.

The possible relationship between Sudeck's atrophy and thickening of the palmar fascia is briefly discussed. In only 1 patient of the 37 was the palmar fascia not thickened or contracted. From the author's observations, it is clear that Sudeck's atrophy is almost always accompanied by an alteration in the palmar fascia which may go on to a typical Dupuytren's contracture.

Three roentgenograms; 4 photographs (3 in color); 4 graphs; 1 table. C. M. GREENWALD, M.D.
Cleveland Clinic

## THE SPINAL CORD

**Lower Extremity Pain Simulating Sciatica. Tumors of the High Thoracic and Cervical Cord as Causes.** Michael Scott. J.A.M.A. **160:** 528–534, Feb. 18, 1956. (225 S. 17th St., Philadelphia 3, Penna.)

Sharp or burning pain referred to a lower extremity and unexplained by extraspinal findings must be investigated for possible intraspinal causation. The author reports 6 cases in which thoracic and cervical lesions of the spinal cord were discovered as the cause for such symptoms. These represented 7 per cent of all tumors of the cervical or upper thoracic spinal cord for which operation was done at Temple University Hospital between 1934 and 1954. One of the tumors was cervical; 5 were thoracic. In all, lower extremity pain was a prominent symptom and in 5 instances the earliest complaint.

The patients were all females over fifty years of age. In 1, sixteen years elapsed between first symptoms and final diagnosis. The pain may be confused with that caused by herniated intervertebral disk or an intraspinal or extraspinal lesion involving the roots of the cauda equina or peripheral portion of the sciatic nerve.

The author describes 1 case in great detail and the other 5 cases quite fully. He stresses the fact that the "burning" quality of pain in the lower extremity should make one include a spinal cord lesion in the differential diagnosis. Investigation of these symptoms should include a complete Pantopaque myelographic study extending to the dorsal and cervical areas if lumbar myelography is negative.

Seven roentgenograms; 1 photomicrograph; 1 drawing; 1 table. JOHN P. FOTOPOULOS, M.D.
Hartford, Conn.

## GYNECOLOGY AND OBSTETRICS

**The Effect of the Full Bladder in Hystero-Salpingography.** A. S. Bligh and E. O. Williams. Brit. J. Radiol. **29:** 99–102, February 1956. (Department of Radiology, United Oxford Hospitals, Oxford, England)

Bladder distention can be an important factor in salpingography. The authors became interested in this problem after seeing a patient who showed no spill initially with what appeared to be a bilateral hydrosalpinx and a full bladder. Following micturition, the tubes descended and spill occurred on the left.

For further investigation of the effect of bladder distention upon the position and filling of the uterus and tubes, 12 unselected patients were catheterized prior to salpingography and the bladder was distended with normal saline (8 to 15 ounces) to the point of discomfort. Routine examination was then performed, and the position of the tubes and their ability to spill were noted before and after bladder emptying. After emptying, descent of the uterus and tubes was seen in 7 cases, descent of the tubes alone in 3, and free spill occurred for the first time in 4 cases.

An attempt to note the effect of a full rectum was abandoned, as it was not found possible to reproduce a physiologically filled rectum.

The authors conclude (*a*) that the position of the tubes can be influenced by a full bladder and that a distended bladder may cause a picture resembling hydrosalpinx; (*b*) that much valuable information regarding the mobility of the tubes may be obtained by noting the influence of a full bladder on tubal position; (*c*) that, if a significant degree of bladder filling is shown on any film, the bladder should be emptied preferably by catheterization before the examination is completed.

Sixteen roentgenograms. C. M. GREENWALD, M.D.
Cleveland Clinic

**Roentgenologic Possibilities and Limitations in the Diagnosis of Parametrial Infiltrations and Pelvic Metastases from Carcinoma of the Cervix.** G. Carnevali, U. Lucarelli, and P. Paracchi. Radiol. med. (Milan) **42:** 113–139, February 1956. (In Italian) (Instituto di Radiologia della Università di Milano, Milan, Italy)

On the strength of various complaints, the most frequent of which was pain, 17 patients with carcinoma of the cervix (11 after intracavitary radium therapy, 6 without previous treatment) were subjected to pneumogynecography (pelvic roentgenography in the Trendelenburg position after diagnostic pneumoperitoneum). To this was added conventional *urography* in 5 cases and *transosseous phlebography* (injection of 50 per cent aqueous iodinated contrast material in the pubis or preferably in the ischium; 20 c.c. unilaterally or 15 c.c. on each side) in 5 cases.

The authors describe the roentgenologic appearance of parametrial infiltrations, of obliteration of Douglas' pouch, and of lymph node metastases in the pelvis. Correlation with palpatory findings facilitates interpretation. Fixed intestinal loops are occasionally seen, but this observation is not necessarily proof of malignant peritoneal involvement, since it could be due to an adhesive inflammatory process. Urographic studies, especially when corroborated by phlebograms, would seem to indicate that the ureters are occluded before closure of the venous channels.

Surgical and/or pathologic confirmation of the findings discussed would have enhanced the significance of this study.

Twenty-one roentgenograms, with schematic drawings. E. R. N. GRIGG, M.D.
Cook County Hospital, Chicago

**Uterine Fibroids.** W. Hodge Dempster. Brit. J. Radiol. **29:** 103–105, February 1956. (Stobhill General Hospital, Glasgow, Scotland)

Considering their frequency, uterine fibroids are rarely demonstrated radiologically. The author believes that the advent of new soft-tissue technics for visualization of the placenta will in time result in more of the larger tumors being visualized. At present, the diagnosis is based on the presence and type of calcification and on displacement of fetal parts in the pregnant uterus. Methods of investigation, in addition to two-

...ne soft-tissue radiography, include cystography, which may reveal rounded pressure defects or irregularities of contour in the bladder, a lateral view following rectal air injection, and hysterography to demonstrate small pedunculated lesions in the non-pregnant uterus.

Three cases are described. One fibroid in a non-pregnant uterus weighed 5.5 kg. and showed typical calcification, making possible its differentiation from an ovarian cyst. Two cases complicated pregnancy, causing fetal displacement, and in one of these there was an abnormal presentation.

A plea is made for an attempt to exclude uterine fibroids as cause for antepartum hemorrhage in women of about forty years of age when placenta praevia is suspected.

Six roentgenograms. C. M. GREENWALD, M.D.
Cleveland Clinic

**Technique for Routine Pelvimetry With Use of a Single X-ray Film.** Herbert Thoms and William C. Billings. J.A.M.A. **160:** 448–451, Feb. 11, 1956. (H. T., 330 Cedar St., New Haven, Conn.)

The authors, on the basis of twenty-five years experience with routine pelvimetry on all primigravidae, state that most women have pelves of adequate capacity for child bearing, but that, on the other hand, palpatory methods alone cannot be relied upon for screening purposes and that subjective impressions thus obtained can be misleading. Midplane and outlet contraction can exist separately or in combination in women with pelves that are otherwise normal in capacity. The procedure proposed here, solely for screening purposes, calls for a single inlet view, which, along with palpatory measures, should provide sufficient information of the pelvic capacity. If additional information is desirable as to pelvic morphology or cephalopelvic relationships, complete roentgen pelvimetry may be done.

The authors discuss some of the general principles of pelvimetry as regards obstetric prognosis, including the factors which play a part in processes of labor and delivery. Mention is made of the mobility of the pelvic joints and the effect of various positions in increasing the pelvic diameters. It is felt that only a reasonable accuracy in pelvimetry is essential and complicated technics which strive to be accurate to the last millimeter have no advantage.

In the routine screening plan here proposed, the following information is obtained: for the *pelvic inlet*, (1) morphological aspects, (2) anteroposterior diameter, (3) transverse diameter, and (4) other inlet diameters if desired; for the *pelvic midplane*, (1) morphology of ischial spines and (2) transverse (interspinous) diameters; for the *pelvic outlet*, (1) morphological aspects, (2) anteroposterior diameter of the outlet, and (3) consideration of available anteroposterior diameter when necessary.

The inlet and midplane assessments are made on a single x-ray film obtained according to the Thoms-Wilson technic (Yale J. Biol. & Med. **13:** 831 1941. Abst. in Radiology **38:** 382, 1942). Two corrected centimeter scales appear on the film. The uppermost scale represents the correction for the plane of the inlet, and the lower scale represents that for a plane 7 cm. below this level, in which rest the ischial spines. Correction at this 7 cm. level has been found sufficiently accurate for all obstetric purposes provided the target-film distance is maintained at 36 inches.

Manual technics are employed to determine (1) the sacral contours and relationships; (2) position and mobility of the coccyx, with determination, also, of the lowest fixed segment in the sacrum or the coccyx; (3) external palpation of the pubic arch for an impression of its amplitude; and (4) determination of the anteroposterior diameter of the outlet.

Outlet contraction manifests itself (1) as a narrowing of the anteroposterior diameter as a result of a general funnel tendency; (2) transversely alone by too prominent ischial spines; (3) anteroposteriorly alone by an unusual convergence forward of the lower sacrum; (4) as a narrowing of the pelvic arch. The available anteroposterior diameter, extending from the apex of a hypothetical pelvic arch to the sacral tip, can be accurately measured roentgenologically by fitting a circular disk representing the average suboccipitobregmatic circumference into the shadow of the arch. When the available anteroposterior diameter is less than 10 cm., the outlet is contracted.

The authors rely on the length of the true anteroposterior diameter to indicate outlet contraction that is not suspected by clinical examination, ruling out serious narrowing if this measures 11.5 cm. or more.

For screening purposes, three groups of pelves are recognized, namely, (1) the dolichopellic, in which the length of the anteroposterior diameter of the inlet exceeds the widest transverse diameter (19 per cent incidence in 1,100 white women); (2) the mesatipellic, in which the anteroposterior diameter of the inlet is less than the transverse by no more than 1 cm. (46 per cent); (3) the brachypellic, in which the anteroposterior diameter of the inlet is from 1.1 to 3.0 cm. less than the transverse diameter (32 per cent).

The list of values below which abnormality is suspected for the "key" diameters is as follows: *For the inlet:* (1) dolichopellic type, anteroposterior diameter less than 12.0 cm., (2) mesatipellic type, less than 11.0 cm., (3) brachypellic type, less than 10.5 cm. *For the midplane:* transverse (interspinous) diameter less than 10.0 cm. *For the outlet:* anteroposterior diameter less than 11.5 cm. (in cases of good pelvic arch amplitude, less than 11.0 cm.). When any one of the five diameters is less than the measurement listed, a lateral pelvic film is obtained. From this, further studies may also be recommended.

One roentgenogram; 1 drawing.
JOHN P. FOTOPOULOS, M.D.
Hartford, Conn.

**Placenta Praevia.** Ragnar Hol. Acta radiol. **45:** 106–116, February 1956. (Roentgen Department, The Red Cross Clinic, Oslo, Norway)

This paper deals with soft-tissue radiography as a principal means of determining the site of the placenta. The supplemental use of the displacement method and cystography are also discussed.

The author first lists certain sources of misinterpretation to be considered. These include lateral obliquity of the uterus, asymmetry of the placental site, placenta membranacea extending over a greater area of the uterine wall, and multiple pregnancy with overlapping of fetal parts. Oblique views may be useful under these conditions. Erroneous diagnoses may be due also to excess of liquor amnii, accidental hemorrhage, placenta bipartita, or a twin pregnancy with two placentas, one of which covers the internal os. Other soft-tissue masses which may be mistaken for a placenta

praevia are pelvic tumors, uterine fibroma, or even the non-pregnant part of a uterus duplex.

Summarizing his discussion of soft-tissue radiography, the author recommends examination of all parts of the uterus by this technic on lateral as well as frontal projections. Exclusion of placenta praevia should be based on the finding of both a characteristic soft-tissue mass in the corpus uteri and normal soft-tissue structures in the pelvic region. Placenta praevia should not be diagnosed with certainty unless local thickening of the intrapelvic uterine wall is observed, consisting in, or in close connection with, a large soft-tissue mass.

Displacement of the fetal head as an indication of placenta praevia has been determined in both the erect and recumbent positions. The author measured the head-promontory and the head-pubis distances in lateral recumbency in 105 women in the eighth and ninth months of pregnancy, in whom a low-lying placenta could be excluded, and reached the following conclusions: The measured values could be compared with figures given by Reid (Brit. J. Radiol. **22**: 551, 643, 1949. Abst. in Radiology **55**: 482, 1950), who examined his patients in the erect position, only when the head stood 2 cm. or more below the pelvic brim. The examination was of less value when the head lay higher. Normally the head-promontory distance should not exceed 1.5 cm. unless a certain amount of gas distends the rectum. The head-pubis distance should not exceed 2 cm. When the pelvis is larger than the average, one may accept the limiting values 2 cm. and 2.5 cm. for the head-promontory and head-pubis distances, respectively.

Cystography was employed for further study of the relationship between the head and the urinary bladder. Normally the maximum distance between the bladder and fetal head is 2.2 cm. A considerable increase in this measurement is noted in total placenta praevia. Cystography was helpful in excluding retention in the urinary bladder, demonstrating its unilateral compression by a soft-tissue mass in the pelvis, giving a better delineation of the lower anterior border of the uterine segment, and in revealing anterior compression of the bladder by a low lying placenta.

Six roentgenograms; 12 drawings; 1 diagram.

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## THE GENITOURINARY SYSTEM

**Tolerance to Contrast Media in Renal Angiography.** Hans Idbohrn. Acta radiol. **45**: 141–154, February 1956. (Roentgendiagnostic Department of the University Hospital of Lund, Lund, Sweden)

There have appeared in the literature numerous reports of injury to the kidney following renal angiography. In spite of this, the procedure is widely accepted as a relatively safe method. The author has systematically investigated a representative series of cases both before and after renal angiography. Before angiography and on each of the three following days, the serum NPN was determined, the urine was studied for albuminuria, and the urinary sediment was examined microscopically. The size of the kidneys was also assessed from conventional roentgenograms taken on each of the first three days following angiography. Altogether 200 cases were investigated.

Of 186 cases in which NPN determinations were made, an increase was noted in 10, in 8 of which it was only slight. Umbradil 50 per cent was used in 2 of these 8 cases, Umbradil 60 per cent in 4, and Triurol 47 per cent in 2. Two cases in which the NPN increased to 102 and 87 mg., respectively, per 100 ml. following the use of Umbradil 60 per cent are reported in detail.

Heller's test for albuminuria was positive in 9 cases and weakly positive in 1, in which Umbradil 60 per cent was used, and positive in 2 and weakly positive in 2 after the use of Triurol 47 to 52 per cent. The total number of examinations was 172.

In the examination of the urinary sediment, special attention was directed to the occurrence of cylinders and casts. The number of cases studied was 171. Cylindruria was observed in 14 of the 106 cases in which Umbradil 60 per cent was used. Of the 49 cases in which Triurol 47 to 52 per cent was used, isolated cylinders were noted in 3. In both groups the cylindruria was transient.

Enlargement of the kidney was noted in 4 patients examined with Umbradil 60 per cent and in 5 with Triurol. One or both of the kidneys showed an increase of about 1 to 1.5 cm. in length or breadth.

It would appear from the above studies that the concentration of the medium is very important and affects the incidence of complications. Fifty per cent Umbradil is less likely to cause complications than 60 per cent. Multiple injections may also play a part in the increased incidence of complications. Experimental evidence suggests that repeated injections of contrast medium within a few days may also contribute to the frequency of renal injury. The author prefers transfemoral catheterization to the translumbar technic. He considers that it is highly unjustified to aim at filling of renal vessels by large amounts of contrast material in high concentration. He stresses also the importance of assessing renal function before submitting a patient to renal angiography. The maximum concentration capacity of the kidney should be at least 1.020 before the study is undertaken.

One table.

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**Solitary Renal Cyst Containing Free Stones Simulating Cholelithiasis.** D. Rees Jensen. Am. J. Surg. **91**: 283–287, February 1956. (Knickerbocker Hospital, New York, N. Y.)

A 54-year-old Chinese male was admitted for apparent infection of the knee joint. An abdominal roentgenogram, in the course of a medical work-up, showed a cluster of faceted stones in the right upper quadrant, presenting a fairly characteristic picture for gallstones. Laboratory findings were suspicious of early obstructive jaundice and low-grade cholecystitis. When oral cholecystography was normal, alternate diagnoses of calcified periduodenal lymph nodes and small gallstones in a secondary gallbladder or cholangiocele were entertained. The observations on intravenous urography were felt to be normal.

When the biliary structures appeared normal at operation, further exploration revealed a cystic mass in the upper pole of the right kidney. The cyst was unroofed and six stones were removed. Pathologic study showed these to be composed of calcium oxalate, phosphate, and urates. In microscopic study the cyst wall was interpreted as "altered renal parenchyma, probably arising from the renal pelvis." The patient made an uneventful recovery.

Etiology, symptomatology, and treatment of solitary cysts of the kidney are briefly reviewed.

Three roentgenograms; 1 photograph; 1 drawing; 1 photomicrograph. JAMES W. BARBER, M.D.
Cheyenne, Wyo.

**Perinephric Abscess Producing a Pneumonephrogram.** Robert Braman and Roland R. Cross, Jr. J. Urol. **75:** 194–197, February 1956. (R. R. C., Jr., 952 N. Michigan Ave., Chicago, Ill.)

The authors present a case of gas-forming perinephric abscess following a severe upper urinary tract infection by *E. coli* in a known diabetic, with gas formation. Roentgenograms demonstrated the renal air pocket and the perirenal air outline. The patient was operated on and the presence of gas and pus was confirmed at surgery. The patient's condition did not permit excision of the kidney but drains were inserted and the wound was packed open. Cultures of the pus showed *E. coli* and *Aerobacter aerogenes*, both of which produced gas on a culture medium. The patient improved and a subsequent retrograde pyelogram revealed almost complete destruction of the diseased kidney.

Six roentgenograms. J. D. GERLACH, M.D.
Cleveland City Hospital

**Calyceal Diverticulum of the Kidney.** A. Heidenblut. Fortschr. a. d. Geb. d. Röntgenstrahlen **84:** 230–234, February 1956. (In German) (Leninallee 140, Berlin 18, Germany)

The calyceal diverticulum is a rare developmental abnormality according to most authors. It was discovered as early as a hundred years ago by the pathologists. In the literature the condition is known chiefly as calyceal cyst. It consists in a small round hollow formation in the renal parenchyma, lined with transitional epithelium. Its pedicle is a thin, narrow channel communicating with the calyceal system.

A calyceal diverticulum is usually an incidental finding during pyelography. It becomes clinically significant, however, when urinary stasis occurs, with subsequent infection and stone formation. In the differential diagnosis a tuberculous cavity is the principal condition to be excluded. Orthograde or head-on projection of a minor calyx may also be mistaken for a calyceal diverticulum, especially when oblique views are not available for clarification.

Four cases are reported in which the finding of a calyceal diverticulum was incidental.

Six roentgenograms. ERNEST KRAFT, M.D.
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**Primary Benign and Malignant Tumors of the Ureter. A Review of the Literature and Report of One Benign and Twelve Malignant Tumors.** B. S. Abeshouse. Am. J. Surg. **91:** 237–271, February 1956. (100 W. Monument St., Baltimore 1, Md.)

The author presents an extensive and detailed account of previously published papers on primary tumors of the ureter and adds 13 cases, previously unreported, from his own experience. All aspects of ureteral tumors are reviewed and discussed. The paper contains a wealth of information gained from data from 454 malignant and 138 benign tumors and is well worth study by those interested in this subject.

Some important conclusions regarding primary tumors of the ureter include the following: Such tumors, though unusual, are by no means rare. The incidence of malignant tumor is twice as great in males as in females and it is most frequently encountered in the sixth decade. Malignant tumors outnumber the benign type three to one. The lower third of the ureter is most commonly involved. The principal malignant pathologic types are transitional-cell papillary carcinoma (72 per cent) and squamous-cell carcinoma (7 per cent). Fully half of the benign tumors are papillomas and most of the remainder are fibromas or polyps. Symptoms produced by ureteral tumors (hematuria, pain, abdominal mass) are non-specific and usually of little aid in diagnosis.

Diagnosis of ureteral tumors is a combined cystoscopic-radiologic problem. The author believes the most important single agent in diagnosis is retrograde ureteropyelography. Characteristic findings for malignant ureteral tumors are irregular obliteration or narrowing of the ureteral lumen over a segment of some length, associated with a mass and various degrees of proximal obstruction. Benign tumors present as sharply localized, intraluminal, smooth-margined filling defects, usually with some proximal obstruction. Differential diagnosis from the radiologic standpoint includes blood clot in the ureter, papillary carcinoma of the renal pelvis with ureteral implant, non-opaque ureteral calculus, and various inflammatory or granulomatous processes.

The treatment of choice for malignant tumors is complete nephro-ureterectomy, with removal of a wide cuff of surrounding bladder tissue at the lower end of the ureter. The author believes so-called "benign papilloma" should be similarly treated because of its potentially malignant nature. Other benign neoplasms of the ureter may be treated by localized conservative surgical measures. The results of operative treatment of malignant lesions still remain disappointing (about 10 per cent five-year survival in this large series) even though improvements in surgical technic have been remarkable in recent years.

Of the author's currently reported 13 cases, 12 were malignant tumors and 1 benign. The malignant group offered no particularly interesting features. The single benign tumor was of interest in that work-up indicated a diagnosis of impacted stone in the upper third of the left ureter. Subsequent operation revealed a pea-sized papilloma inspissated with calcium salts.

Seven roentgenograms; 1 photograph; 5 tables.
JAMES W. BARBER, M.D.
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**Radiographic Estimation of Residual Urine in Children.** Bradford W. Young, William L. Anderson, and Gordon G. King. J. Urol. **75:** 263–272, February 1956. (B. W. Y., 490 Post St., San Francisco 2, Calif.)

To determine the presence of residual urine in children, the authors instill 5 c.c. of "ascendent" Lipiodol (iodine content 11 cg./c.c.) into the bladder by catheter and obtain films immediately thereafter, at twenty-four hours, and again at forty-eight hours if indicated. While both upright and supine films are taken, the former are in general more accurate because of the layering of the oil, permitting visualization of smaller amounts of the residual Lipiodol. The kidneys should be included on the film because of the possibility of reflux of the oil due to incompetency of the ureteral valves.

Of a series of 20 children, 9 showed residual urine after

twenty-four hours or longer. In all 9 decompensation of the detrusor mechanism was present due to vesical neck or subvesical obstruction of a mechanical, neurogenic, or inflammatory nature. Four of the group had congenital contractures of the vesical neck, 3 had neurogenic bladders, 1 had a severe cystitis-urethritis, and 1 had a bilateral congenital ureterovesical junction obstruction. As was shown in the case of cystitis, a subsequent internal sphincter spasm causing urinary retention should be ruled out by means of urethral dilatation, antibiotics, and antispasmodics, before wedge resection of the vesical neck. Reflux of Lipiodol into the kidney was observed in 3 cases, in all of which there was residual urine. Though hydronephrosis was present in 2 of these patients the refluxed oil had disappeared from the kidney after seven to eleven days.

In the adult, the standard test for residual urine is simple and reliable. In children, however, this test is not accurate, because (1) of their inability to void on command (emotional factors; inability to understand) and (2) doubt as to complete voiding. Cystoscopic examination for diagnosis of vesical neck obstruction can be misleading because of the relative size of the vesical neck and the fact that minor trabeculation may be mistaken for normal bladder muscle striations.

The actual volume of the retained urine is less important than the fact of its presence, since it is not essential to know the degree of decompensation but merely that it exists. No unfavorable effects followed the procedure in the children examined.

Twenty-seven roentgenograms; 1 chart.

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**Some Studies of Urinary Incontinence in Men.** Francis A. Beneventi and Victor F. Marshall. J. Urol. **75:** 273–284, February 1956. (F. A. B., 65 E. 76 St., New York, N. Y.).

The urinary sphincters and their actions are so poorly understood that ideal correction of severe post-prostatectomy incontinence is not often achieved. To obtain information on these matters, the authors carried out histologic and radiographic studies. For the former they obtained specimens consisting of the bladder, prostate, membranous urethra, and much of the surrounding tissues, from cadavers of 4 males aged seven, twelve, nineteen, and forty years of age. Multiple sections were made from these specimens and then stained for microscopic analysis.

It was found that the external sphincter of striated muscle consisted of a thick ring around the membranous urethra which spread over the apex of the prostate and constituted part of the prostatic capsule. This striated muscle sent many extensions down into the glandular substance in a somewhat rib-like pattern. No clearly defined circumferential band of muscle, either smooth or striated, was found at the vesical outlet. In short, the external striated sphincter was thick and extensive and not a thin iris-like structure.

Voiding urethrograms showed that the usual abrupt elevation of the vesical base on voluntary interruption of the urinary stream is not essential for perfect continence. It was further shown that mobility of the levator ani muscles may be of some importance in maintaining control. The external sphincter of continent men moved upward and downward for as much as 1 inch while the subject voluntarily started and stopped the stream. This new observation does not fit the popular conception of a sphincter inside a fixed triangular ligament.

Twenty-four roentgenograms; 4 drawings; 3 photographs.

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**Sphincterometrography. A New Technique for Studying the Physiology and Pathology of Urinary Incontinence in the Female.** Abdel Fattah Youssef and Mahmoud M. Mahfouz. J. Obst. & Gynaec. Brit. Emp. **63:** 19–25, February 1956.

Sphincterometrography is a term coined by the authors to define their method for measuring the physiologic strength of the female urethral sphincters. A double-channeled rubber tube, a variant of the Miller-Abbott tube, is inserted through the urethra. The larger channel empties directly into the bladder, and the smaller channel communicates with the balloon of the tube. The bladder is filled with 150 c.c. of 5 per cent sodium iodide solution and the balloon is filled with 40 c.c. of a 25 per cent solution and then pulled down until it lies at the base of the bladder in the region of the internal meatus. The different concentrations permit identification on the roentgenograms.

The channel filling the bladder is connected to a manometer and the pressure recorded. The usual intravesical pressure at rest, under the conditions noted, was found to be about 10 cm. of water. An anteroposterior radiograph is made at this initial pressure. The patient is then asked to strain and, when the intravesical pressure reaches 30 cm. of water, another film is obtained. She then strains to capacity and a third radiograph is made at the peak of intravesical pressure, which usually ranges from 60 to 80 cm. of water. The following three points are studied on the films: (1) level of the bladder base; (2) the presence of funneling of the bladder base; (3) descent of the balloon below the level of the bladder base, into the urethra.

More than 100 such sphincterometrographic assessments were made on patients at the Department of Obstetrics and Gynecology and the Institute of Radiology, Kasr El Aini Hospital, Cairo University, Egypt. Nulliparous and multiparous women, normal and with varying degrees of prolapse, with or without stress incontinence, were studied. Also examined were women in the first week after delivery, normal and abnormal.

The method was found to possess several advantages: (1) It has yielded useful information concerning the physiology of urinary continence in the female and the relative importance of the different components of the sphincter mechanism. (*a*) No increase in the intravesical pressure can lead to incontinence if the sphincter mechanism is intact. (*b*) The internal (vesical) sphincter is by far the most important factor in the maintenance of continence. (*c*) The intrinsic voluntary muscle of the urethra and the external sphincter of the urethra (compressor urethrae) play only a subsidiary role in the maintenance of continence. (*d*) No sphincter mechanism exists in the part of the urethra distal to the urogenital diaphragm. (*e*) The level of the bladder base and the presence of absence of funneling have no direct relation to the maintenance of continence. (2) It is useful in the diagnosis of the type and severity of incontinence. In conditions such as urgency incontinence and neurogenic bladder, with an intact sphincter mechanism, the balloon always remains within the bladder base, however high the intravesical

pressure may be. (3) The method is helpful in planning operative treatment for the individual case. (4) It is valuable for assessment of the results of treatment in cases of stress incontinence. (5) Sphincterometrographic assessment of cases of stress incontinence before and after operation may prove helpful in comparing the value of different operative procedures performed by different authorities on cases which differ in nature and severity. (6) Sphincterometrographic examination of women in the first week after labour has revealed certain points of interest which may elucidate the causes of later prolapse or incontinence.

Twelve roentgenograms; 2 photographs.

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**The Closure of the Female Urethra.** G. M. Ardran, C. A. Simmons, and J. H. Stewart. J. Obst. & Gynaec. Brit. Emp. **63**: 26–35, February 1956. (Oxford United Hospitals, Oxford, England)

The opening and closing of the female urethra were studied by rapid serial radiography in 27 subjects. Eleven had no disorders of micturition; 16 suffered from stress incontinence. Previous to these studies the authors had investigated stress incontinence by means of barium urethrocystography in 120 subjects. In order to "catch" the opening and closing of the urethra the rapid serial radiography of the present study was needed.

Barium urethrocystography was done by catheterizing the patients and injecting a barium sulfate suspension into the bladder until there was a sensation of fullness. At the same time a little of the suspension was instilled into the rectum and a barium paste was smeared on the vaginal walls. Rapid serial radiography in the lateral projection, with an image intensifier, was then done to study the function and relationship of the base of the bladder, urethra, vagina, and rectum during such acts as sitting without muscular effort, straining, coughing, voiding, and involuntary or voluntary interruption of the urinary stream. No complications developed from the use of barium sulfate. The bladder cleanses itself.

The following conclusions are drawn by the authors:

(1) The urethra appears to be empty at rest except for a small "beak" of contrast medium projecting into the internal meatus.

(2) During straining the "beak" may increase slightly; in patients suffering from stress incontinence of urine, the urethra may fill to a varying degree. On cessation of straining the urethral contents are returned to the bladder.

(3) With interruption of the stream the external sphincter closes first and the contents of the proximal two-thirds of the urethra are returned to the bladder by progressive obliteration of the lumen.

(4) A posterior urethrovesical angle of less than 180 degrees is usually present at the beginning of voiding in patients with or without stress incontinence.

Eleven roentgenograms; 29 tracings from serial films.

MORTIMER R. CAMIEL, M.D.
Brooklyn, N. Y.

**Cystitis Emphysematosa: Case Report.** James W. Lane and Paul Francke. J. Urol. **75**: 256–260, February 1956. (St. Francis Hospital, Charleston, West Va.)

A case of cystitis emphysematosa is reported which is believed to be the twenty-third in the literature to be discovered during life. Cystitis emphysematosa is the presence of inflammation and gas within the wall of the urinary bladder. This patient was thought to have appendicitis but because of pyuria was treated with Gantrisin. After a marked response to this treatment, a radiograph of the abdomen was obtained. This showed numerous small areas of emphysema within the bladder wall. Cystoscopic examination confirmed the presence of small air-filled vesicles within the fundus of the bladder, in the submucosa, ranging up to 1 cm. in diameter.

The authors state that, as in their case, cystitis emphysematosa is usually mild, of short duration, and associated with a urinary infection by either the colon bacillus or *Clostridium welchii*. Twelve of the 23 reported cases were in diabetics. The authors' patient was a chronic alcoholic.

Four roentgenograms; 1 photograph.

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## TECHNIC

**A Moving Vertical Grid Suited for Very Short Exposures.** Ove Mattsson. Acta radiol. **45**: 133–140, February 1956. (Roentgendiagnostic Department, Karolinska Sjukhuset, Stockholm, Sweden)

Attention is directed to the disturbing influence of the break in continuity of film depiction as a result of the stationary grid pattern. To avoid this, the author has devised a grid mechanism for vertical stands with a reciprocating motion permitting exposures down to 0.01 second with a four-valve unit. This mechanism is controlled automatically from the control table. There is no need for adjustment of time nor any setting of springs.

The author demonstrates chest films taken with a stationary grid, and likewise with his moving grid, when the exposure time was 0.01 sec. During the short exposure peak the grid is seen to have moved sufficiently to produce complete freedom from pattern. A grid with a ratio of 1 to 8 centered for 110 cm. was employed. In general, it would appear that this grid permits the elimination of grid pattern in examinations in which previously a stationary grid was the rule. It extends the possibility of high-voltage technic.

Five roentgenograms; 2 diagrams; 3 photographs.

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**Seeing in the Dark.** Martin Weiser. Röntgen-Blätter **9**: 33–41, February 1956. (In German) (Schleiden, Eifel, Germany)

The retina includes 120 to 130 million rods, 6 to 7 million cones, and 9 million optic nerve terminals. At the periphery, every nerve terminal is connected to several hundred rods and many cones. The fovea centralis contains only cones (about 135,000), some 35,000 of which compose the most sensitive spot, the foveola: here each optic terminal services a single cone. This arrangement corroborates the physiologic fact that the foveola is the site of resolution; the lower limit of distinct perception averages five arc minutes for points, one arc minute for elongated objects. For the same reason, clear vision is restricted to an area of about 1 sq. cm.; when we look at a long word or figure,

only a few letters or numerals are well seen and, although training makes us unaware of this fact, our eye must "wander" over the entire length for proper assessment.

The threshold of light perception is lower at the periphery of the retina than on the fovea. Two photons of light must be absorbed in 0.1 second to produce a sensation on the nerve terminal. On parafoveal vision, subliminal stimuli are summated because a single nerve terminal collects the impressions received by several hundred cells. Likewise, motion is earlier and better detected by peripheral vision (warning function).

The aging process diminishes the elasticity of the iris, and thus reduces the degree of potential mydriasis. When maximally dilated (complete adaptation), the pupillary diameter averages at twenty years 8 mm, at forty years 6 mm, at sixty years 4.1 mm, and at eighty years 2.5 mm. In terms of transmitted light, this would amount at twenty years to twice more than at forty, at forty years to twice more than at sixty, and at sixty years to three times more than at eighty. With 2 ma at 45 to 55 kv, a junior physician will see roentgenoscopic details in the chest for which a senior might have to use 3 ma and 60 to 70 kv. Since all vital processes slow down with advancing age, an older person may need a longer time to reach a given level of adaptation. Further individual variations in depth and speed of adaptation to the dark, proved to exist under experimental conditions, could be due to differences in the tonus of the vegetative nervous system and/or to other (unknown) factors.

As expected, the circle of clear vision is quite restricted during roentgenoscopy. Moreover, many sections of the luminescent screen do not emit a sufficient number of light photons for resolution by the cones of the foveola. Parafoveal vision, which "sees" at much lower levels of dimness, has no resolving power. Research work is necessary to determine (*a*) how much detail is lost by pupillary narrowing due to advancing age (knowing that there is also the compensating factor of increased experience!) and (*b*) how significant is the difference in speed of adaptation by age groups. So far, our incomplete physiological knowledge does not permit an adequate discussion of roentgenoscopy. This might explain the contradictory statements and unfounded claims scattered in the literature devoted to this topic.

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## RADIOTHERAPY

**Combined Roentgen and Radium Therapy of Urethral Carcinoma.** Sven Hultberg. Strahlentherapie **99:** 171–184, February 1956. (In German) (Radiumhemmet, Karolinska Sjukhuset, Stockholm, Sweden)

Carcinoma of the urethra is a rare disease with a poor prognosis. Surgery has been disappointing because of the low survival rate and has therefore been almost completely abandoned. Teleradium therapy, with local application of seeds or radium emanation, has also been found inadequate. The five-year survival rate was only 2 out of 29 cases.

The author studied the records at the Radiumhemmet (Stockholm) and found 50 cases, including 2 in males, between 1918 and 1944. Fourteen additional cases have been treated since 1945. Most patients were in an advanced stage of the disease. While formerly surgery and teleradium were used, the new method (in the 14 more recent cases) consisted mainly of deep roentgen therapy alone or occasionally in combination with radium seeds. The technical factors were two to four converging vulvar fields, 40 to 50 sq. cm.; h.v.l. 1.0 mm. Cu; single skin dose of 500 r, with a total of 2,000 r for each of the four fields. Dosimetry with applied thimble chambers revealed a total dose of 5,500 r at the urethral orifice and 3,200 to 3,800 r in the depth of the urethra.

The results have been more satisfactory with the new method, with a four-year survival in 7 out of 9 cases.

Eight photographs; 3 drawings.

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**The Treatment of Hemangioma Chiefly by Irradiation.** George E. Pfahler. Arch. Dermat. **72:** 425–437, November 1955. (1930 Chestnut St., Philadelphia, Penna.)

The author of this paper, who states that he has been interested in the treatment of hemangioma since 1913, and in the use of radium for that purpose since 1918, reviews here the general principles involved and their adaptation to the individual case. He reaffirms his conviction, expressed elsewhere (see, for example, Radiology **46:** 159, 1946), that these lesions "should be treated as early in life as practical, preferably within the first few months. The great majority are best treated by irradiation. For most of the lesions the gamma radiation from radium will give the most satisfactory cosmetic results, but at times this radium treatment should be supplemented by high-voltage x-rays, and at times the high-voltage-ray treatment is preferable to any other."

Five groups of before-and-after photographs.

**Histiocytic Granulomatosis.** Walter Mercer and R. B. Duthie. J. Bone & Joint Surg. **38-B:** 279–292, February 1956. (Edinburgh, Scotland)

An interesting case of histiocytic granulomatosis is reported by the authors. This title is favored because the permanent and constant pathological feature is the presence of numerous histiocytes and granulomatous tissue. Pathological evidence from biopsies carried out chronologically during a six-year period demonstrated transformation from a histiocytic granulomatous stage with eosinophils predominating to a lipoid granulomatous stage with "foam cells" predominant.

The patient, first seen at age thirty-one, showed involvement of both skeletal and extraskeletal tissues. The latter feature was represented by an asymptomatic generalized diffuse miliary infiltration of the lung fields, which remained unchanged over the six years. There were cystic areas of destruction in the skull, pelvis, femora, scapulae, and humeri. Pathological fractures of both femora failed to heal over a three-year period, and finally required saucerization of the diseased areas and packing with bone chips.

Radiotherapy was tried at an early stage without much response. Reports from other sources vary as to the effects of irradiation. Lichtenstein (Arch. Path.

**56:** 84, 1953. Abst. in Radiology **62:** 782, 1954) points out the difficulty of evaluating treatment for such a condition, with its varied expressions of stage, severity, distribution, and age of patient. He also suggests that roentgen therapy may accelerate the change from an eosinophilic stage to that of a lipoid granuloma. This point could not be established in this case except that on the ealier biopsy, as mentioned above, the picture was that of a histiocytic granuloma with numerous eosinophils and eighteen months later it was that of a lipoid granuloma.

This case is felt to provide further proof of the concept of the interrelation of eosinophilic granuloma and lipoid granulomatosis (Hand-Schüller-Christian disease, chronic disseminated histiocytosis).

Ten roentgenograms; 8 photomicrographs (4 in color); 1 drawing.

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**Radiation in the Therapy of Peptic Ulcer.** J. W. J. Carpender, Erwin Levin, Charles B. Clayman, and Roscoe E. Miller. Am. J. Roentgenol. **75:** 374–379, February 1956. (J. W. J. C., 950 E. 59 St., Chicago 37, Ill.)

One hundred sixteen patients with gastric ulcer and 113 with duodenal ulcer were selected for roentgen therapy and have been followed over a period of five to ten years with an evaluation of immediate and late results. All patients received roentgen therapy (h.v.l. 1.5 mm. Cu) through one anterior and one posterior field carefully directed to the gastric fundus and body. Calculation of depth doses indicated about 1,600 to 1,700 r delivered to the stomach in ten days. A few selected patients received a second course of irradiation after one year or more had passed. Several of the patients complained of nausea during therapy and most of them showed a mild erythema over the treatment portals. Otherwise, no reactions were encountered.

*Gastric Ulcer:* Of the 116 patients treated and followed, all had had at least one ulcer recurrence on standard regimes of diet and antacids prior to radiotherapy. Almost all were over forty years of age. In 41 cases achlorhydria lasting up to six months was produced and in all these instances the ulcer healed. In 34 cases a permanent reduction of acid gastric secretion of more than 50 per cent was obtained and most of these patients remained free of subsequent ulcer recurrence. Decrease in acid secretion usually appeared about one month after completion of radiotherapy. Only 10 per cent of the irradiated patients showed no effect on acid secretion. The authors feel that complications of gastric ulcer (hemorrhage, perforation, etc.) were less frequent and less severe in their group of irradiated patients than in ulcer patients in general. Carcinoma of the stomach subsequently developed in 1.7 per cent of the series, but this incidence is thought to be the same as in ulcer patients who have received no radiation.

*Duodenal Ulcers:* All of the 113 patients in this group had had one or more recurrences on the usual ulcer management. Histamine achlorhydria was induced in 23 per cent of the series following radiotherapy with an effect which lasted from six months to a few years. Ulcers healed in all of these cases and no recurrences had been found at the time of the report. An additional 34 per cent had more than 50 per cent reduction in concentration of free hydrochloric acid lasting six or more months, and in all of these cases also the ulcers healed. In some, recurrences developed on return of normal acidity and in 10 per cent subsequent surgery was required. In none of the group irradiated for duodenal ulcer did carcinoma of the stomach develop.

*In summary,* 53 per cent of the gastric ulcer patients have had no recurrence to date and 66 per cent of the duodenal ulcer group have remained healed. Conclusions are that radiotherapy to the body and fundus of the stomach for peptic ulcer is a useful and safe adjunct to medical treatment.

Eight tables.

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**A Method of Calculating Isodose Curves from Central Axis Depth Dose Data.** F. W. Tranter. Brit. J. Radiol. **29:** 92–94, February 1956. (Christie Hospital, Manchester, England)

The author, in a rather technical article, describes a method which permits calculation of isodose curves from any self-consistent depth dose data such as are presented in the recent Survey of Central Axis Depth Dose Data (Supplement 5, Brit. J. Radiol.).

The calculation of the depth dose at a point in an irradiated field involves the integration of the scatter reaching that point and the primary component. Some form of extrapolation is always necessary for calculation of the scatter reaching the edges of the larger fields. Where extrapolation of the scatter:radius curve is performed, a formula is usually used as a guide. Lamerton and Winsborough (Brit. J. Radiol. **23:** 236, 1950) have shown how a scatter:radius curve may be represented on polar graph paper by a series of annuli contributing equal amounts of scatter to the central axis at the depth considered. Radial lines divide the annuli in equi-contribution sectors, which are counted to obtain the total scatter from a field. The author makes use of an experimental method of "extrapolating" the scatter:radius curve, with extension of these curves to large radii. A separate chart is required at each depth, for each h.v.l., and for each focal-skin distance.

This method applies to fields of any shape both at medium energies and in the megavoltage region. Its advantages are simplicity and speed in use, with the basic charts readily prepared, requiring only compasses and a protractor. They can be quickly replaced if the central axis data change.

Five figures.

C. M. GREENWALD, M.D.
Cleveland Clinic

**The Use of a Scintillation Counter in the Determination of Isodose Curves of Radium Applicators.** Archimíro Caha, V. Prokeš, and J. Dadok. Československ. Roentgenol. **9:** 89–94, 1955. (In Czech)

When a probe is small enough (4.7 mm. diameter as used in this series), it can be inserted into the bladder or rectum to measure the dose with a radium applicator in place. The probe employed by the authors contained a wolframite crystal with a diameter of 1.8 mm. The instrumentation included the usual photomultiplier tube, high-voltage source, and scaler; the circuit used seemed very sensitive to changes in the high-voltage supply (1 per cent in the high-voltage corresponding with 7 per cent deviation in the final result).

The authors use routinely a radium applicator with 6 × 5 mg. in the colpostats and a tandem with 3 × 10

mg. After insertion of the applicator, films are exposed in frontal and lateral projections. The conditions are reproduced on a phantom, and measurements are performed with the scintillation counter described, the results being recorded as isodose curves. Check points may be obtained by comparison with dose measurements in the patient's bladder and rectum.

Four drawings.

VICTOR J. FISH, M.D.
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**Dosage Estimation in Radiotherapy and the Wheatley Integrator.** Boyce Worthley, John Tooze, Joan Brown, and Robert M. Fry. Acta radiol. Suppl. 128, 1955. (Physics Section of the Anti-Cancer Campaign Committee, The University of Adelaide, Adelaide, Australia)

In 1951 (Brit. J. Radiol. **24**: 388, 1951), Wheatley described a method of estimating radiation dosage by means of optical integration which could be used for x-ray fields of any size and shape. The authors of this supplement have extended its field of application to many other problems in radiotherapy. The handling of problems in the x-ray field is based on the Meredith and Neary analysis and includes grids, wedge filters, and fields with sections blocked out. Tables are given for M and λ. The method is applied to estimation of integral dose and to dose at the axis of rotation for different positions of the axis in the body. Under gamma ray dosimetry, linear sources, both uniformly loaded and end-loaded, are considered, as well as volumes treated by planes of both types of needles.

The reader is referred to the original for details of the theory and construction of the Wheatley optical integrator and for the mathematics involved.

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## RADIOISOTOPES

**Mediastinal Lymph Node Irradiation with Radioactive Gold.** H. Brownell Wheeler, William E. Jaques, Marshall B. Allen, Maury Soltes, Vincent J. O'Conor, Jr., and Harrison Black. Surg., Gynec. & Obst. **102**: 166–176, February 1956. (Peter Bent Brigham Hospital, Boston, Mass.)

It was felt that the administration of intrapulmonary radioactive colloidal gold ($Au^{198}$) might be helpful as an adjunct to surgery in the treatment of bronchogenic carcinoma. The radioactive gold supposedly would be picked up in the lymphatics and carried to the regional lymph nodes, where theoretically the radiation would destroy the metastases.

Experiments designed to substantiate this premise were carried out on a group of 25 normal dogs. In 8 animals colloidal $Au^{198}$ coated with a layer of metallic silver a few molecules thick (so that the particles might be more easily picked up by the lymphatics) was sprayed directly into a segmental bronchus in insufflations of from 4.5 to 100 millicuries. Seventeen animals were given a submucosal injection in a lobar bronchus, of 5 to 25 millicuries of $Au^{198}$. It was necessary to design a special 50 cm., 21 gauge needle with a short bevel in order to proceed with the submucosal injections. The dogs were sacrificed at various intervals and the pathologic changes produced and the distribution of the radioactivity were studied.

The two different methods of administration resulted in dissimilar gross and microscopic changes in the pulmonary parenchyma. Advanced pulmonary changes were found in the lungs of the dogs treated by the endobronchial insufflation method. These changes extended to adjacent lobes and even to the opposite lung. In dogs receiving submucosal injections, however, the histopathologic changes were limited to the injection site. The histologic changes in the regional lymph nodes and their specific activity showed good correlation. Nodal damage was more extensive and more nodes were involved following submucosal injection than after bronchial insufflation. The liver, spleen, kidneys, and thoracic vertebral bodies were studied in these animals, and the changes were minimal.

The distribution of radioactivity was determined by gross autoradiographs and by direct counting of the ashed tissues. In general, dogs receiving $Au^{198}$ by the intrapulmonary route showed localization of radioactivity in the lobes originally sprayed, although there was definite nodal concentration. Negligible amounts of radioactivity were found in the bone marrow and other organs of the body. The lymphatic pick-up of the gold was delayed, reaching a maximum in from ten to twelve days.

Dogs which received gold by means of submucosal injections showed minimal pulmonary concentrations and a much higher nodal pick-up. The maximal node concentration here occurred in only three days. The involvement of other organ systems was insignificant.

In both types of gold administration, the radioactivity in general appeared to be concentrated along the most direct path of lymphatic drainage, although this pattern was not constant from dog to dog. No severe toxic effects were encountered as a result of the $Au^{198}$ dosage. In 1 animal pneumonia developed following bronchial insufflation and several dogs had transient coughs.

Since over 90 per cent of the radiation of gold 198 is due to beta particles with a mean penetration of 0.38 mm., and because the gamma dose is so small, this type of therapy is not suitable for large tumors unless the injection is made directly into the tumor itself. Likewise, control of extensive nodal metastases would probably meet with failure because of lymphatic obstruction, as well as the short penetration of beta radiation.

The experimental data do indicate, however, that it might be possible to destroy small metastatic lymph node deposits before they are detectable grossly. It would seem logical to attempt clinical trial of submucosal injections of $Au^{198}$ prior to lobectomy or pneumonectomy in selected cases of bronchogenic carcinoma with the hope of destroying microscopic lymphatic metastases.

Two autoradiographs; 10 photomicrographs; 1 graph; 3 tables.

DAVID J. STEPHENSON, M.D.
University of Pennsylvania

**Mechanisms of Hydronephrosis: Radioautographic Backflow Patterns.** Lester Persky, Frederick J. Bonte, and George Austen, Jr. J. Urol. **75**: 190–193, February 1956. (L. P., 2065 Adelbert Rd., Cleveland 6, Ohio)

By means of isotopic tracer materials, it was shown,

in a series of 10 dogs, that $I^{131}$ and colloidal $Au^{198}$ were able to gain access to the blood stream quickly from the kidney pelvis after ligation of the ureter. For the experiment the ureter was exposed as closely as possible to the ureteropelvic junction and ligated about a specially designed needle with a central cannula and two associated hypodermic needles, which permitted inflow and outflow from the kidney pelvis. A manometer was attached to the central cannula. The pelvic contents were replaced with iodinated albumin, and radioautographs were obtained after freezing and sectioning the kidney. In 5 of the animals the pelvis was ligated after the injections while in the other 5 it was permitted to empty.

It was found that the backflow pattern in the radioautographs were of two types: pyelotubular backflow in 2 of the 10 animals and a combination of pyelotubular with pyelointerstitial backflow in 8. The presence or absence of residual radioactive material within the pelvis did not modify the picture.

An excellent discussion follows the account of the experiment, comparing the results with observations on man. The authors conclude that in the dog pyelotubular and pyelointerstitial backflow occur early and that a rapid entrance of the pelvic contents into the blood stream takes place, as shown by the prompt appearance of radioactivity in the peripheral blood.

Four radioautographs; 2 photographs.

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**The Uptake of Phosphorus 32 by the Knee Joint and Tibia of Six-Week-Old Mice and the Effect of X Rays Upon It. Variation of Uptake with Time After a Dose of 2000 r of 200 kV X Rays.** C. W. Wilson. Brit. J. Radiol. **29:** 86–91, February 1956. (Westminster Hospital, London, S. W., England)

One of the few satisfactory methods of measuring the effect of radiation upon bone is in terms of the effect produced upon its uptake of $P^{32}$. A dose of 2,000 r of 200-kv radiation was delivered to the left hind knee joint and tibia of six-week-old mice. The animals were then injected intraperitoneally with $P^{32}$ at known intervals after irradiation up to twenty-two weeks. They were sacrificed one to two hours after injection, preliminary study having shown that $P^{32}$ uptake was maximal within this interval. The right hind leg of each mouse served as the un-irradiated control.

It was shown that in the knee joint there was a latent period of about one week, after which the uptake of $P^{32}$ fell progressively, to reach a minimum value of about 55 per cent after four weeks. This depression was maintained until some eight to ten weeks after irradiation, following which a slow recovery seemed to occur. This was still incomplete at the end of twenty-two weeks. A simple visual demonstration of this reduction of $P^{32}$ uptake proved possible by means of macroscopic autoradiography.

These results are compared with data obtained by Woodard and Spiers (Brit. J. Radiol. **26:** 38, 1953), who irradiated rats under similar experimental conditions, to study alkaline phosphatase activity. It is believed that the primary action of irradiation is depression of the osteoblast. This is followed by immediate and increasing depression of alkaline phosphatase activity, as might be expected since the osteoblast is necessary for elaboration of this enzyme. In turn, the alkaline phosphatase is necessary for true calcification to occur. Since the $P^{32}$ uptake is explicable to a large extent in terms of ionic exchange at the small bone crystal surfaces, the depressed uptake caused by irradiation can be attributed to a reduction in the amount of surface-active new bone available for participation in this ionic exchange. Thus the latent period of about one week before $P^{32}$ uptake is depressed can represent the time required for cell destruction (and consequent reduction in alkaline phosphatase) to be reflected as a depression of true calcification.

In the tibia, similar effects of a like magnitude were observed but they developed more slowly. This difference may be related to differences between the growth activity of the knee joint and tibia.

One autoradiograph; 4 graphs; 1 diagram; 1 table.

C. M. GREENWALD, M.D.
Cleveland Clinic

**Blood Volume in Patients with Laennec's Cirrhosis of the Liver as Determined by Radioactive Chromium-Tagged Red Cells.** Seymour Eisenberg, with the technical assistance of Mary Sue McCall. Am. J. Med. **20:** 189–195, February 1956. (Department of Internal Medicine, University of Texas, Dallas, Texas)

Changes in blood volume incident to the development of Laennec's disease of the liver have never been clearly elucidated. It has been generally accepted that patients with the disease show an increase in total blood volume, primarily as a result of expansion of the plasma space. In the present study, blood volume, red cell mass, and plasma volume determinations were carried out in 20 patients with Laennec's cirrhosis of the liver by the radiochromium-labeled red cell technic. This method would appear to have certain advantages over previously employed labeling procedures, such as T-1824 dye and $P^{32}$, since the stability of the $Cr^{51}$ red cell complex does not permit accession of the reference material into the plasma space, as in the case of $P^{32}$, or into the lymphatic space, as in the case of T-1824 dye.

Repeat observations were made in 12 patients following the disappearance of ascites with clinical improvement; in this manner, comparisons between untreated and treated patients with cirrhosis were possible, as well as comparisons between patients with cirrhosis and a group of 20 normal patients.

A significant increase in plasma volume was found only in patients with esophageal varices and/or cyanosis; all measured functions were normal in other patients. Plasma volume and red cell mass were increased in 4 cirrhotic subjects with cyanosis. There was no evidence of true anemia (defined as a true decrease in circulating red cell mass) nor did there occur a significant rise in red cell mass following clinical improvement. No consistent change in plasma volume following the recession of ascites was observed.

The study of another patient prior to and following the establishment of a portocaval shunt is reported in an addendum.

Seven tables.

## RADIATION EFFECTS

**Gastric Carcinoma Following Abdominal X-Ray Therapy.** Kenneth C. Olson, Andrew A. Gage, and William M. Chardack. Gastroenterology **30:** 12–20, January 1956. (University of Buffalo School of Medicine, Buffalo, N. Y.)

A 62-year-old male was admitted to the Veterans Administration Hospital in Buffalo in June 1950. In 1943 he had experienced epigastric pain and weight loss and a gastrointestinal x-ray study had led to a diagnosis of advanced carcinoma of the stomach. He was at that time given a course of high-voltage x-ray therapy, totaling 1,137 r. His symptoms disappeared and he returned to work.

In October 1935, he was again hospitalized because of abdominal pain, and a tender mass the size of an orange was found in the left upper quadrant. At exploration the fundus of the stomach was seen to be involved in a large nodular mass which was considered to be a malignant tumor, although a biopsy was not done. Between November 1935 and February 1936, 7,500 r were delivered to the tumor area through anterior, lateral, and posterior ports. On follow-up examination three months later there were no complaints and no tumor was palpable. Roentgen studies, however, showed a marked deformity of the middle third of the stomach. In view of the patient's good clinical course, it was felt that the lesion was probably a lymphosarcoma rather than a carcinoma of the stomach. In 1937 an additional 3,000 r was delivered through right oblique and left superior ports.

At the time of admission to the Buffalo VA Hospital in June 1950, roentgenograms showed contraction of the distal two-thirds of the stomach. The overlying skin was atrophied and eroded. Throughout 1951, the patient experienced episodes of severe gastric bleeding, and in December exploratory laparotomy was undertaken. The stomach wall was indurated and thickened, particularly anteriorly, and a high subtotal gastric resection was performed. To both the surgeon and the pathologist the gross specimen appeared to be an example of radiation gastritis. Microscopic examination, however, uncovered an undifferentiated carcinoma infiltrating throughout the resected stomach. Death ensued on the thirtieth postoperative day.

The authors of this paper believe it unlikely that the tumor found at the time of resection represented the original lesion observed sixteen years previously, for "carcinoma of the stomach pursues, indeed, a very different course." They bring up the possibility that the original lesion might well have been a lymphosarcoma (since they feel it most unlikely that the patient received fifteen years of palliation from x-ray therapy alone for carcinoma of the stomach) or a benign gastric ulcer. They consider that the circumstantial evidence suggests that the carcinoma arose as a result of the radiation which was administered to the stomach.

This case is discussed further in an editorial in the same issue of *Gastroenterology* (pp. 130–132), signed by Drs. Walter L. Palmer, Joseph Kirsner, and Charles B. Clayman of the Department of Medicine of the University of Chicago. They believe it possible the patient may have had a slow-growing carcinoma which was fairly well controlled by massive radiation. They cite their experiences with radiation therapy of duodenal ulcer to support the view that radiation has never been proved to be a cause of gastric carcinoma. They have administered x-rays, in dosages ranging from 1,100 to 1,700 r to the body and fundus of the stomach in approximately 1,300 patients over a period of eighteen years. In only one patient in the entire series is carcinoma of the stomach known to have developed, and this they believe was unrelated to the irradiation.

[One other point which the editorial makes is that a carcinoma might well have responded favorably to such massive radiation as the total figure cited of 11,637 r. However, the authors obtained that figure by adding the dosages given in 1934, in 1935–6, and in 1937, without giving definite data to support their right to compute the dosage in this manner. The only time they mention "tumor" dose is in reporting the 1935–6 treatments. Another factor in the development of the patient's radiation dermatitis, not mentioned by the authors, might very well be the additional radiation received in the area from the numerous upper gastrointestinal x-ray studies which he received.—A. S. T.]

Five roentgenograms; 3 photographs; 1 photomicrograph.

ARTHUR S. TUCKER, M.D.
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**A Study of Late Radiation Necrosis Following Therapy of Skin Cancer.** H. L. Traenkle. Arch. Dermat. **72:** 446–453, November 1955. (Roswell Park Memorial Institute, University of Buffalo, Buffalo, N. Y.)

This study is concerned with 55 instances of late radiation necrosis observed among 935 cases of skin cancer treated with roentgen rays between 1946 and 1953. In none of these was dosage considered excessive, and in no instance was more than one course of therapy given. The following treatment schedules were employed:

*Schedule A:* 1,000 r × 4 (4,000 r total dose), eight to ten days overall treatment time.

*Schedule B:* 1,000 r × 5 (5,000 r total dose), ten to twelve days overall treatment time.

*Schedule C:* 500 r × 9 (4,500 r total dose), fractional doses given almost daily over eleven-day period.

*Schedule D:* 400 r × 12 (4,800 r total dose), fractional doses given almost daily over a fourteen-day period.

Between 1946 and 1950, Schedule A was used routinely in most cases of skin cancer and for some of the smaller lip cancers; Schedule B was employed principally in the treatment of lip cancer. Because of the high frequency of necrosis encountered, it was felt that the use of smaller fractions and a slight prolongation of overall treatment time might make for increased tissue tolerance. Accordingly, from 1950 to 1953 Schedules C and D were employed routinely. Whether or not smaller fractionation of the total dose will result in fewer instances of late necrotic breakdown is not yet apparent.

The interval between the completion of therapy and the onset of reactions ranged from four months to six years, with well over 50 per cent occurring more than two years after the completion of therapy. In 50 of the cases (90 per cent) there was spontaneous remission.

While it was not possible to compare the incidence of necrosis with the various field sizes, it is considered noteworthy that these reactions did occur in very small fields. The material suggests that some anatomic

sites, such as the eyelids, canthi, and alae of the nose are less tolerant of roentgen rays in cancerocidal dosage than are other areas.

Of the etiologic possibilities investigated, exposure to cold appears to have been a factor in many of the author's cases, with more than 65 per cent of the late necrotic reactions occurring during the colder part of the year. It is reasonable to assume that the vasoconstriction induced by cold is sufficient to produce marked ischemia, with subsequent necrosis in an irradiation scar already poor in blood supply. Similarly, prolonged exposure to strong sunlight and possibly trauma may act as trigger mechanisms in initiating inflammation and necrosis in a previously intact irradiation scar.

It appears that even when conservative roentgen therapy is administered for skin cancer, some degree of late inflammation and necrosis in the irradiated field ultimately develops in a disturbingly high percentage of cases.

Three graphs; 3 photographs; 2 tables.

**Lung Changes After Rotational Therapy of Intrathoracic Tumors.** Hermann Werkgartner. Strahlentherapie **99:** 327–337, February 1956. (In German) (Zentral-Röntgeninstitut der Universität Wien, Vienna, Austria)

Since the introduction of rotation roentgen therapy the author has treated 44 chest tumors with the new technic. Physical factors were 200 kvp, 0.7 mm. Cu h.v.l., and a pendulum angle of 330 degrees in the cases cited. The tumor dose varied from 5,000 r to 7,000 r. Twenty-nine cases have been evaluated statistically. In 3 there was marked pulmonary change following irradiation; in 7 others slight damage was observed. In 2 cases changes appeared one month and in 5 two months after completion of therapy. In the remaining 3 cases the interval was three months.

In carcinoma of the esophagus the tolerance was better than in bronchogenic carcinoma. In the latter condition, the incidence of pneumonitis was 41 per cent of all treated cases; in the former 18.2 per cent.

Radiation pneumonitis in bronchogenic carcinoma was most pronounced peripheral to the stenosing neoplasm at the site of pre-existing post-stenotic infection. In a few cases the contralateral healthy lung also showed radiation pneumonitis which, however, was mild and proved to be reversible. In several autopsy cases radiation pneumonitis, characterized by severe interstitial fibrosis, was found to be most intense in the central hilar area and less pronounced in the periphery toward the visceral pleura. In this region an exudative reaction predominated.

Five roentgenograms; 1 drawing.

ERNEST KRAFT, M.D.
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**Roentgen Sarcoma. Report of a Case.** Vera Andersen. Acta radiol. **45:** 155–160, February 1956. (Radium Centre, Copenhagen, Denmark)

The author reports the third case of irradiation sarcoma to be discovered at the Radium Center in Copenhagen since 1913. Up to 1952 only 2 of the 21 irradiation cancers were sarcomas.

The present case, diagnosed in 1954, followed numerous x-ray treatments to the hands for an eczematous condition, between 1920 and 1923. Dosage and quality of radiation are unknown. The malignant lesion on the dorsum of the left hand measured 3.5 × 4.5 cm. and was fixed to but did not destroy underlying tendons and bones. The patient had been treated for radiation dermatitis since 1936. The microscopic picture was one of polymorphocellular fibrosarcoma, and amputation of the forearm was carried out.

The minimum sarcomatogenic dose is unknown, but it would appear to be high enough to produce chronic atrophic radiodermatitis. The shortest reported time between roentgen therapy and development of sarcoma is about three years, and the longest about forty-one years.

One photograph; 2 photomicrographs.

DAMON D. BLAKE, M.D.
Bowman Gray School of Medicine

**Initial Radiation Syndrome in the Adult Chicken.** S. Phyllis Stearner, Margaret Sanderson, Emily J. Christian, and Austin M. Brues. Am. J. Physiol. **184:** 134–140, January 1956. (Argonne National Laboratory, Box 299, Lemont, Ill.)

The initial response of the adult rooster to roentgen radiation was studied and compared, on the basis of survival, circulatory changes, and renal function, to the initial response of young chicks. In the adult rooster, the dose-rate-dependent early mortality that follows irradiation was found to be similar to that reported for young chicks, but the severe hypotension previously observed in chicks (Am. J. Physiol. **182:** 407, 1955. Abst. in Radiology **66:** 930, 1956) was not seen in the older birds. Although a small drop in blood pressure occurred within thirty to sixty minutes after exposure, a critical hypotension was not seen during the initial postirradiation period.

Both twenty-four-hour survivors and non-survivors showed an increase in urate excretion during the first ten to twelve hours after irradiation. Apparently, the slight fall in blood pressure that occurred after x-ray exposure was not sufficient to affect renal function directly. In addition, the epithelium of the adult kidney is less radiosensitive than that in the young chick; histopathologic changes are minimal.

Although no serious hypotension was observed during the initial postirradiation period in the adult, there was qualitative clinical evidence of a circulatory insufficiency with pooling of blood in peripheral organs. In irradiated chicks a similar condition is accompanied by severe hypotension. Results of experiments on hemorrhagic shock, however, indicate that the adult can compensate for much greater loss of circulating volume without a decrease in blood pressure than can the young chick.

Three photomicrographs; 4 graphs; 4 tables.

**Effect of Total-Body X-Irradiation on Fat Balance and Liver Lipids in the Rhesus Monkey.** John G. Coniglio, W. J. Darby, J. Ann Efner, Jim Fleming, and Granville W. Hudson. Am. J. Physiol. **184:** 113–118, January 1956. (Vanderbilt University School of Medicine, Nashville, Tenn.)

Fat balance studies were done on 10 Rhesus monkeys receiving 325, 400, and 600 r total-body x-irradiation. The post-irradiation results were compared with the pre-irradiation values in the same animals and with those obtained in pair-fed controls.

No defect in fat absorption was found to follow irradiation. A slight increase in fecal fat loss was observed, but this did not differ significantly from that in non-irradiated controls. Monkeys given 650 r were

found at autopsy, after twelve, ninety-six, and two hundred twenty-nine days, to have liver lipid concentrations similar to their pair-fed controls. Changes in body weight in all animals paralleled decreases in food intake immediately after irradiation and subsequent increases with recovery. Hematologic studies showed the usual decrease in leukocyte count after irradiation. One monkey given 650 r was killed twelve days post-irradiation because death was imminent; the other animals survived the irradiation.

Three graphs; 2 tables.

**Histopathology of the Irradiated Hibernating Ground Squirrel.** Frank W. Fitch, John Doull, and Robert W. Wissler. Arch. Path. **60:** 644–650, December 1955. (Departments of Pathology and Pharmacology, University of Chicago, Chicago, Ill.)

Groups of hibernating and non-hibernating ground squirrels were given 800 r single-dose total-body x-irradiation and sacrificed at various intervals after exposure. Histologic findings in these animals were compared with suitable controls.

It was found that hibernation prolonged survival time in the animals subjected to total-body irradiation but had no effect upon the ultimate mortality rate. The principal cellular changes occurred in the hematopoietic system, which showed evidence of damage occurring with the same rapidity and to the same extent in both groups. There was a delay in removal of nuclear debris from the reticuloendothelial organs of hibernating animals and absence of the anemia and leukopenia which occurred in control groups. No evidence to suggest that development of cellular damage was dependent upon body temperature could be found. There was indirect evidence of a greater degree of preservation of mature leukocytes and erythrocytes in the bone marrow of the hibernating animal after irradiation. It was concluded that suppression of bacterial growth and resulting infection and bacteremia were the most important factors in prolongation of the survival time.

Eight photomicrographs.

ROBERT B. CONNOR, M.D.
University of Texas, Dallas

**Influence of Low-Voltage X-Radiation on Regression of Established Corneal Vessels.** I. C. Michaelson and H. Schreiber. Arch. Ophth. **55:** 48–51, January 1956. (I. C. M., Hadassah Medical Organization, Box 499, Jerusalem, Israel)

Previous experiments have shown that low-voltage x-radiation in appropriate doses can *inhibit* new-vessel growth into the cornea (Scheie *et al.*: Am. J. Ophth. **33:** 549, 1950. Abst. in Radiology **56:** 797, 1951; Michaelson *et al.*: Arch. Ophth. **52:** 77, 1954. Abst. in Radiology **64:** 795, 1955), but fails to *prevent* it altogether (Michaelson). In the investigation described here, the authors undertook to determine the effect of radiation on regression or already established corneal vessels in rabbits.

It was found that total doses of low-voltage x-radiation ranging from 700 r to 2,400 r have no regressive effect on established corneal vessels, even after a waiting period of from two to six weeks. The dose of 2,400 r was not only ineffective in causing regression of vessel growth but appeared actually to stimulate it.

Two figures; 4 tables.

**Further Studies of Effects of X-Radiation on Partially Shielded Lens of Rabbit.** P. J. Leinfelder and E. F. Riley. Arch. Ophth. **55:** 84–86, January 1956. (State University of Iowa College of Medicine, Iowa City, Iowa)

Previous experiments by one of the authors demonstrated that low doses of x-radiation to one quadrant of the lens in rabbits results in opacity limited to the area of exposure (Alter and Leinfelder: Arch. Ophth. **49:** 257, 1953. Abst. in Radiology **62:** 158, 1954). In this study, in an attempt to produce rapidly an overwhelming effect in one sector of the lens, considerably larger doses of radiation were utilized.

X-ray exposure factors were 200 kv, 5 ma, 27 cm. distance, 150 r per minute, and 1 mm. Al filtration. Lens exposure was limited by a lead shield, sutured to the sclera of the anesthetized rabbit; the remainder of the animal was shielded with sheet lead.

Doses of x-radiation as high as 12,000 r produced only partial cataract in the exposed portion of the lens when two or three of the lens quadrants were shielded. Complete opacity was observed in no instance, nor did opacities occur in the untreated quadrants of the lens. The latent period ranged from approximately two weeks to six months, varying inversely with the dose used. Little difference was noted in the degree of cataract produced by 3,000, 5,000, and 12,000 r.

Eight illustrations; 1 table.

**Time Trend of Hyperlipoproteinemia After Radiation Injury.** Norman Weiner, Harry G. Albaum, Lawrence J. Milch, and the Cardiovascular Research Group, Randolph Field, Texas. Arch. Path. **60:** 621–627, December 1955. (Department of Pharmacology-Biochemistry, School of Aviation Medicine, Randolph Air Force Base, Randolph Field, Texas)

Significant increases in plasma cholesterol, phospholipids, and low density lipoproteins have been found to occur following acute radiation injury in the experimental animal. A decline in the phospholipid-cholesterol ratio has also been noted in contrast to the normal ratio observed after other types of injury.

The authors investigated the plasma lipid changes in a group of albino rabbits given an acute dose of roentgen radiation, 20,000 r (air) in a single exposure (260 kvp, T.S.D. of 29 cm., inherent filtration of 0.025 mm. Cu). In these animals hyperlipoproteinemia developed during the first week after exposure, followed by a recession of plasma lipoprotein level between the eleventh and fifteenth days and a second rise during the third week. This change paralleled the gross, microscopic, and chemical changes in the irradiated tissue characterized by a latent period, a period of destruction and dissolution, a period of resorption, and ultimately fibrosis at the site of injury. There was also noted a parallelism between hyperlipoproteinemia and weight loss.

The mechanism of development of elevated plasma lipoprotein was not determined, but several etiologic possibilities are considered; for example, initiation of lipoprotein synthesis due to dissolution and absorption of muscle protein; a release of cholesterol and lipoproteins; actual synthesis of lipids by the injured muscle; supervening infection and necrosis.

Ten figures.

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**Morphology of the Amorphous Intercellular Substance of Hematopoietic Tissues.** Eve Perl Reaven. Arch. Path. **60:** 610–615, December 1955. (Departments of Anatomy and Pediatrics, University of Chicago, Chicago, Ill.)

An amorphous intercellular substance has been identified by various investigators in the hematopoietic tissues in pathologic states. In an attempt to obtain more information on this "ground substance," the author studied the lymphatic tissues and bone marrow of experimental animals before and after hemorrhage and x-irradiation. By means of a special stain the amorphous intercellular substance was identified in the lymphatic tissues and bone marrow of normal untreated animals. In the lymphatic tissues, after hemorhage and irradiation, this substance filled the spaces vacated by the death, removal, or migration of cells. In the bone marrow, the intercellular substance filled in the depleted cellular areas in the specimen taken shortly after blood loss, but an increased cellularity was observed in later specimens. The intercellular material remained stainable up to one week. Following x-irradiation, there was a concomitant prominence of the intercellular substance as cellular depletion occurred. This change continued for approximately one week, until the abundant ground substance produced a "gelatinous" marrow.

A difference in staining quality of the intercellular substance was observed in the abnormal tissues following hemorrhage and irradiation, as compared with normal tissues, stainability being greater in the former. Increased staining capacity indicated that new ground substance was being formed and deposited.

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**Influence of X-Irradiation Upon Water Consumption by the Rat.** Douglas E. Smith and Ella B. Tyree. Am. J. Physiol. **184:** 127–133, January 1956. (Argonne National Laboratory, Box 299, Lemont, Ill.)

Water consumption was measured daily (*a*) after single total-body exposures of intact and adrenalectomized rats to x-radiation and (*b*) after single, partial-body exposures of intact rats. Beginning the first day after exposure, there occurred increases and decreases in water consumption which were related to x-ray dosage and to the portion of the body irradiated. The individual variation in response was very high. Adrenalectomy abolished the polydipsia which immediately follows irradiation. The possible influence of the pituitary-adrenal system upon the irradiation-induced changes in water consumption is discussed.

Both hypophysectomized and normal rats showed a decrease in consumption of sucrose (20 per cent), when this was the sole source of fluid, following irradiation.

Four graphs; 5 tables.

**A Sign of Severe Radiation Injury Observed in the Erythrocyte Sedimentation of Dogs.** George A. Sacher. Blood **11:** 174–183, February 1956. (Argonne National Laboratory, Box 299, Lemont, Ill.)

Two phases of response were demonstrated in the erythrocyte sedimentation reaction following radiation injury in dogs. In construction of the sedimentation curves, the two constants of the ascending branch are expressed in the slope-intercept form

$$\log S = a \log t + \log S_{10}$$

where $a$ is the slope of the log-log regression line and $S_{10}$ is the ten-minute intercept.

Phase I occurred in the first ten days, with a decrease in slope in the sedimentation curve accompanied by increase in intercept. From the tenth day through the nineteenth there was further increase in intercept accompanied by increase in slope (Phase II). Of interest would be the observation that the second response was obtained following radiations beyond the fractional lethal range.

Decrease in the slope of sedimentation indicates an increase in the rate of rouleaux formation. It is inferred that a decrease in hematocrit brings about Phase I and that Phase II is due to an increased titer of an agglutinating principle.

Six graphs.

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